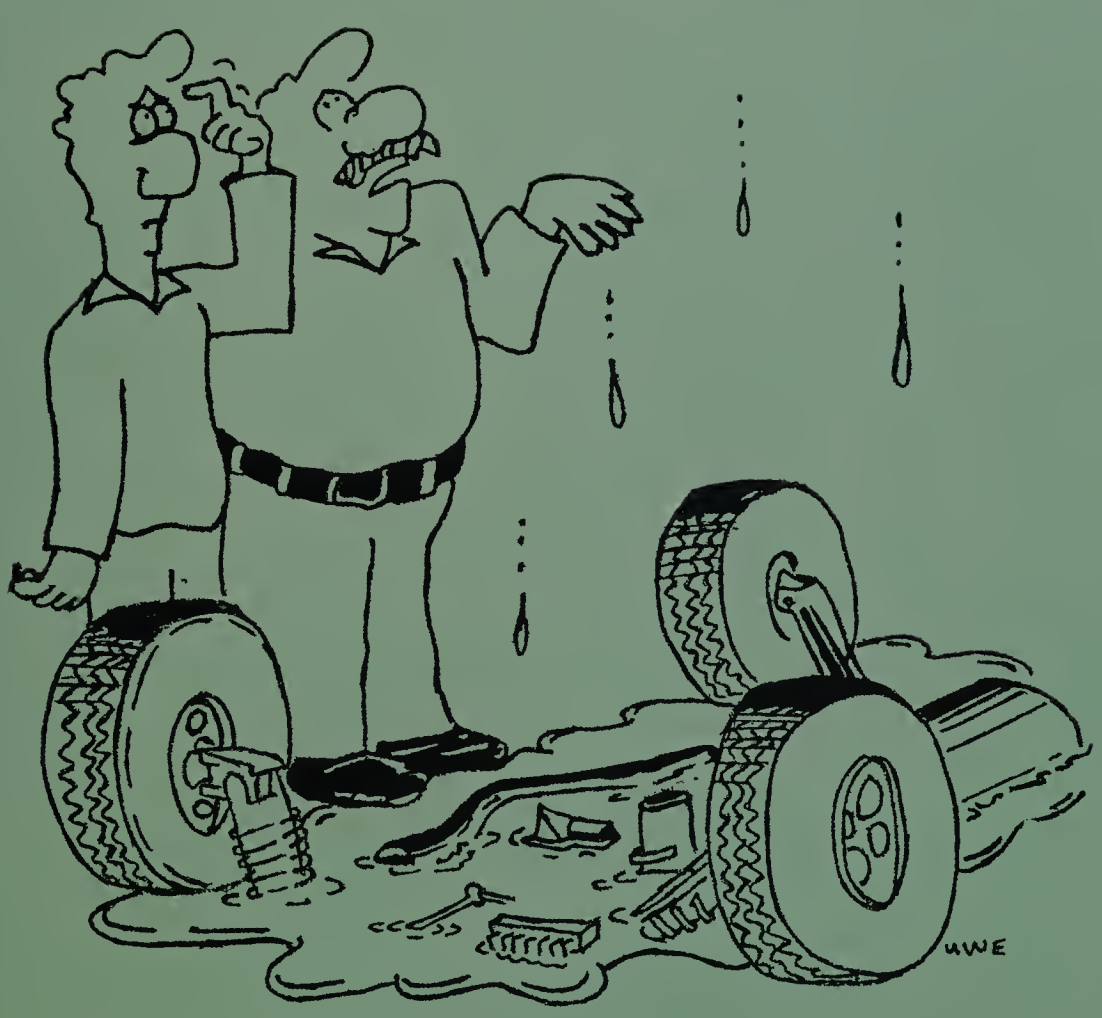
Chemistry International

The news magazine of the International Union of Pure and Applied Chemistry (IUPAC)



ACID RAIN AND OTHER INTERNATIONAL PROBLEMS:
HOW TO ASSESS THE RISK, AND WHAT SHOULD BE DONE

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CHEMISTRY INTERNATIONAL

The news magazine of the International Union of Pure and Applied Chemistry (IUPAC)

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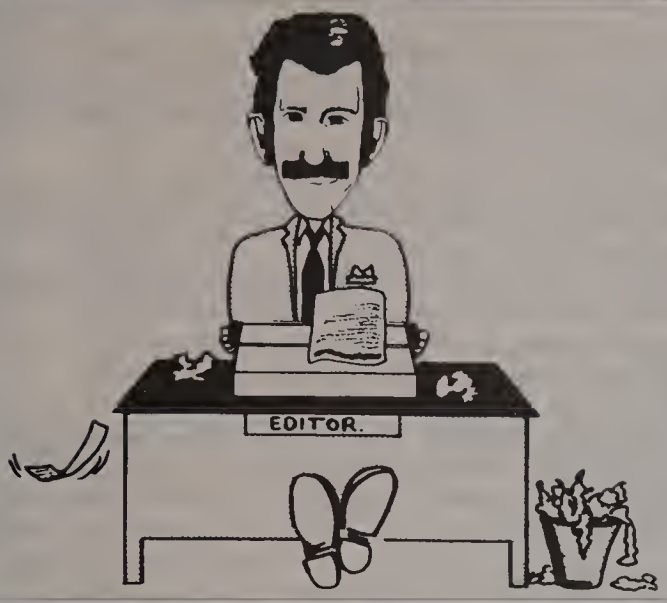

THE EDITOR'S DESK

Opinions expressed here are those of the author, and do not necessarily reflect the views or policy of IUPAC.

A taste of things to come

Many of the 4000 million people on Earth are vegetarians, either by necessity or choice. In the developing world, many people subsist almost entirely on a diet of cereal grains. Among them, protein-calorie malnutrition is a serious problem: it stunts physical growth and mental development, and weakens resistance to disease. Chronic malnutrition leads to frequent, disabling sickness and partly accounts for the high death rates and low economic productivity in the developing world.

Nutrient-deficient diets are not, however, confined to the developing world. There are an estimated 10 million vegetarians, mostly young adults, in the United States alone. Many others with marginal nutrition, due to poor eating habits or poverty, could also benefit from high-protein low-cost meat substitutes made by simple fermentation technology developed in localized areas of the Third World.

Prof. Keith Steinkraus, a microbiologist at Cornell University's Agriculture Experiment Station, explains that only recently have Western countries and the developing world begun to appreciate indigenous methods for producing high-protein foods at the village level. Acceptance of these foods has, in the past, been confined by cultural and geographical barriers. Rarely have they been accepted even in neighbouring countries. **"It would be a mistake"**, *Prof. Steinkraus emphasized in his recent paper*,* **"not to recognize the part prestige plays in acceptance of foods, not only for the rich, but also for the poor."** *He recalled his experience with tempeh, an indigenous fermented food of Indonesia:*

"It has only been since the Western world began to research and use Indonesian tempeh that the topic has gained enough prestige to encourage Indonesian scientists to research their own foods. An Indonesian scientist told me that, in the past, he would not have had the nerve to approach his administration with the suggestion that he work on this familiar fermented food because be would have been refused permission."

Prof. Steinkraus and coworkers were able to apply modern food processing methods to the traditional tempeh manufacturing process so that it could be (and now is) produced by small factories in Western countries. Using modern heat treatment methods, grinders and fermentation incubators, Prof. Steinkraus and other researchers were able to produce tempeh with the same high nutritive value and pleasant dough-like aroma of traditional Indonesian tempeh. Their methods have now been adopted by some Indonesian factories.

Tempeh is produced by growing the edible mould **Rhizopus oligosporus** *on a soybean cake. The fermentation enhances its flavour, upgrades the content of protein and vitamin B-12, increases digestibility by solubilizing protein and fats, and improves the texture by knitting the soybeans into a compact cake. The tempeh product is deep-fried or*

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Tempeh soybean cake is a low-cost meat substitute that, for centuries, has been made in village-scale factories and widely consumed in Indonesia. It is made from soybeans which are soaked, dehulled, partially cooked, and overgrown with the edible mould *Rhizopus oligosporus*. The mould strands (mycelia), which contain a high protein content, knit the soybeans into a compact cake. During growth of the mould, a bacterial fermentation produces vitamin B-12. This is extremely important for vegetarians, whose diet might otherwise be deficient in this important vitamin. Tempeh has been adopted as the major protein source in at least five vegetarian communes in the United States, and is now produced commercially in at least 35 small factories in the USA and Canada (*photo courtesy of Prof. Keith Steinkraus, New York State College of Agriculture & Life Sciences, USA*).

cut into chunks and eaten in soups. Fried tempeh has an agreeable slightly nutty flavour. In short, the fermentation process extends the range of flavours, texture and nutrition that can be attained with soybean foods, much as widely-used fermentation technology allows milk to be converted into many types of cheese, yoghurt and dairy products.

Many other food fermentation processes are also capable of enhancing the nutrition, flavour and texture of vegetable material, yet their use has remained restricted almost entirely to the few localized regions where they have been consumed for centuries. Prof. Steinkraus described a few of these foods:

"The Indonesians have developed methods to convert food processing byproducts, such as peanut and coconut press cakes, which the Western world has traditionally fed to animals, to high-quality foods called 'ontjom' and 'bongkrek' . . . These products are low-cost protein-rich meat analogues."

"Indonesians successfully grow edible microbes on starch substrates. They make 'tapé ketella' from cassava, and 'tapé ketam' from rice. Unfermented cassava contains only 1 - 2% protein, not an adequate amount to meet human protein requirements, yet millions of the world's very poor use cassava as a major staple food. Fermentation to tapé ketella upgrades the protein content to 4 - 8%, enhances the level of thiamine and lysine, and produces acids, alcohols and esters which impart an improved flavour. The production of tapé ketella and tapé ketan could be extended to other countries."

"These indigenous fermented food processes offer a unique opportunity for increasing the quantity and quality of protein in areas of the world where the staple food is composed largely of starch."

The potential benefits and opportunities are by no means limited to developing countries. Fermentation technology could be adopted into developed countries—enriching the variety, as well as nutrition, of the diet. Non-traditional foods could be prepared with imported mould cultures, or wholly new food products introduced. Novel fermentation technology has now been developed and tested to make microbial meat analogues from vegetable starch (see feature article in this issue). These products will provide unexplored opportunities for food chemists, budget conscious consumers, food processors and gourmets. Their introduction will be a development that all of us can relish.

**Production of microbial protein foods on edible substrates, food by-products, and ligno-cellulosic wastes, by K. H. Steinkraus. Published in "Bioconversion of Organic Residues for Rural Communities," Food & Nutrition Bulletin Supplement 2 (Nov. 1979), United Nations University.*

Global and regional problems are assessed for cooperative action

Concern about the risks of chemical contamination, pesticides, oil spills, ozone depletion and other dangers is leading to the emergence of a new species of government official—the risk assessors. Their job, as stipulated in the report *Environmental Risk Assessment**[1] by the Scientific Committee on Problems of the Environment (SCOPE), is to identify risks, estimate their magnitude and evaluate their consequences and probabilities. They must compare the risks of manufacturing and using pesticides, drugs, fluorocarbons and other chemicals with the benefits to society. A knowledgeable decision can then be made on the alternatives to reduce the risk (bearing in mind their effectiveness and cost), or the decision made *not* to intervene.

The decisions are often not simple. The risk of using a certain pesticide, for example, must be weighed against crop destruction that will follow abstinence from pesticide use, or the risks and costs of alternative pesticides and pest control methods. Indeed, the identification of a risk does not necessarily mean that preventative measures are called for. The aim, as authors of the report explain, is not to eliminate risk, but to allocate resources (usually money) in the way that causes the maximum overall reduction of risk to society, with the minimum reduction in living standards.

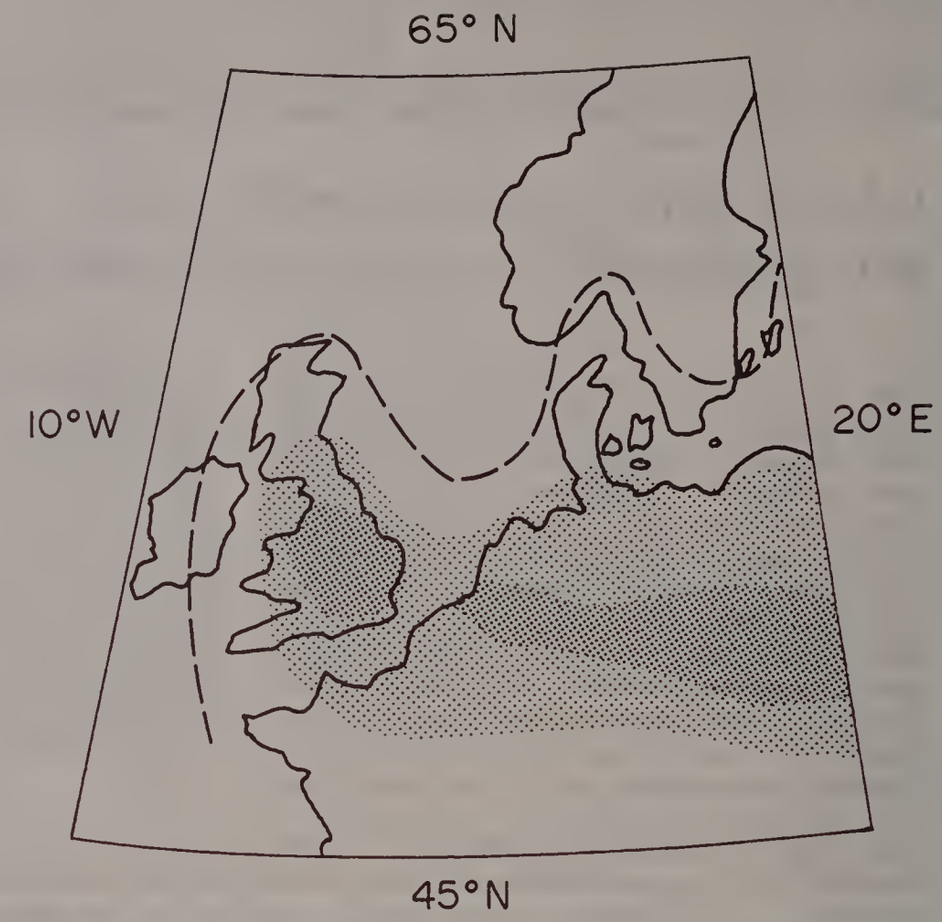
Where to direct maximum effort to reduce risk is difficult to decide because there is no agreed scale to measure, and compare, risks. Even when the best solution is apparent, economic and political barriers may prevent allocation of resources in those applications where they are most needed. But progress is being made. "Risk assessment" was once considered entirely the concern of industrialized countries. It is now recognized that assessment of environmental risks is as important, perhaps even more important, in developing countries. Industrial development, expansion of agricultural production and urbanization are exacerbating the hazards of erosion, overgrazing, deforestation, inadequate water supplies, air pollution and industrial waste disposal. The SCOPE report states that "Less than a decade ago the work that is now being done by international environmental organizations like SCOPE and UNEP (United Nations Environment Programme) would have been considered utopian. Their establishment reflects a growing awareness among nations that the *common interests* of mankind in the face of growing environmental hazards outweigh national or regional interests."

The global nature of many environmental problems has become apparent in recent years. DDT residues are found nearly everywhere on Earth (including in the bodies of Antarctic penguins), and depletion of the Earth's ozone layer by fluorocarbons potentially affects the atmosphere and climate of every country. Worldwide, 6 - 8 million tons of carbon dioxide are released into the atmosphere by the burning of fossil fuels and the destruction of forests, raising the level of carbon dioxide in the atmosphere at an alarming rate (3% per decade).

Pollution is rarely confined to the air and waterways of one country. It often creates regional problems. For example, sulfur dioxide emission in Europe has continued to increase, and the damage it causes is often borne by countries that are not major polluters. Industrial nations have generally sought to reduce health risks associated with sulfur dioxide by building taller stacks at industrial plants. This has successfully reduced local sulfur dioxide concentrations in populated and heavily industrialized areas, but has dispersed effluents over extensive areas. It has become recognized in recent years that sulfur dioxide can cause detrimental effects at great distances from the source. There has been widespread acidification (lowered pH) of rain and snow in Europe and Eastern North America. In the northern USA and southern Canada, pollutants may accumulate in snow during the winter season, causing a surge in acidity when snows begin to melt in the spring. In large areas of North America and Western Europe, many thousands of lakes will become virtually devoid of fish and aquatic life if emissions of sulfur dioxide continue.

Sulfur dioxide represents a classic example of trans-border dispersal of pollutants requiring international cooperation. It remains to be resolved how much sulfur dioxide emissions could be reduced, at what price, and who pays. As is characteristic of trans-border pollution problems, the nations in which emissions originate are reluctant to spend money to protect their neighbors. One encouraging example is provided by the Scandinavian countries, which have considerably reduced their own sulfur dioxide emissions and are calling for an international agreement to reduce air pollution in Europe.

Many other examples of trans-border problems are cited in the SCOPE report: pollution of the lower Rhine in Holland with effluents from German and Swiss industries upstream; the development of locust swarms and other pest infestations in one country and their



Acid fumes of sulfur dioxide are carried across national boundaries by air currents. Here, average ground-level concentrations of sulfur-dioxide are shown for Western Europe. Sulfur dioxide concentrations are more than 10 $\mu g/m^3$ within the heavily shaded area, 5 $\mu g/m^3$ within the shaded area, and 2.5 $\mu g/m^3$ within the dashed line. Average SO_2 concentrations in the air above the South Atlantic and Indian oceans have been measured to be about 0.05 $\mu g/m^3$ *(diagram adapted from SCOPE report 7, "Nitrogen, Phosphorus and Sulfur—Global Cycles").*

migration to devour crops in another; the construction of the Farrakka Barrage on the lower Ganges by India, diverting water which would otherwise flow into Bangladesh. Perhaps the most universal and serious problem is desertification. About sixty million people live on the margins of present deserts and are subject to risks of drought and spread of the desert onto arable land. Climatic fluctuations have been exacerbated by deforestation, overgrazing, deep-well drilling and firewood gathering. At least half the countries of the world and 30% of the world's land surface are affected by desertification: many of the nations that are threatened lack the economic resources to combat desert encroachment.

It has been suggested that desert areas created by human activities now comprise 6.7% of the world's surface, an area larger than Brazil. In the southern Sahara alone, 650 000 square kilometres of land suitable for agriculture or grazing have become desert over the last 50 years. The Atacama Desert in northern Chile is advancing 1.5 - 3 kilometres each year, and the Thar Desert in India was estimated to have been enlarging at the rate of 0.8 kilometres/year for a period of 50 years.

Even highly localized problems can have international aspects. The contamination of crops by automobile lead emissions is confined mostly to farmland very near to main roads, yet international trade of foodstuffs broadens the problem to international dimensions. Standards for permissible lead levels in foodstuffs may differ, and the diligence with which these levels are enforced varies even more. Food grown and contaminated in one country may be exported to another.

The problems are not limited to transferring resources from one country to another. Even within one country, there are often enormous differences in the amount spent to eliminate risk and save lives in different industries. A great deal of money is spent on safety and safe plant design in the chemical industry. To raise

Cartoon by Uwe Oehler is reproduced courtesy of "Chem 13 News"

the level of safety even further in the chemical process industry would cost an estimated US$2 million for each life saved. While additional safety in the chemical and process industries is clearly desirable, states Prof. T. A. Kletz in his article *Benefits and Risks: Their assessment in relation to human needs*[*2], he believes the money would be better spent improving safety in coal mining and construction (which are relatively hazardous industries), road transportation, or persuading people not to smoke cigarettes. Also, the money might be spent on better health care, where (contrary to a common assumption) lives can be saved at much lower cost than in industry (in 1972, cervical cancer screening cost US$3000 for each life saved; breast cancer screening cost US$6000 per life saved; and intensive care units cost US$10 000 to operate for each life saved).

"Unfortunately", as Prof. Kletz points out, "if the process industries spend less on safety, there is no social mechanism by which the money saved could be allocated to, say, the mines or roads. Also, society does not advance in any field by marching uniformly over a broad front. It improves by spear-heading; one firm or industry goes out in front and shows what can be done, and the rest follow. . . Nevertheless, some levelling out is perhaps desirable."

"Safety can be bought, but only at a price. The more we spend on safety, the less we have with which to fight poverty and disease, or to spend on those goods or services which make life worth living for ourselves and others. Whatever money we make available for safety, we should spend (it) in such a way that it produces maximum benefit to our fellow men."

[*1] *Environmental Risk Assessment (SCOPE 15), Edited by Anne V. Whyte and Ian Burton, 1980, published by John Wiley & Sons for the Scientific Committee on Problems of the Environment of the International Council of Scientific Unions.*

[*2] *Benefits and Risks: Their assessment in relation to human needs, by T. A. Kletz, published in "Endeavor" and reproduced in the Bulletin of the International Atomic Energy Agency, October 1980.*

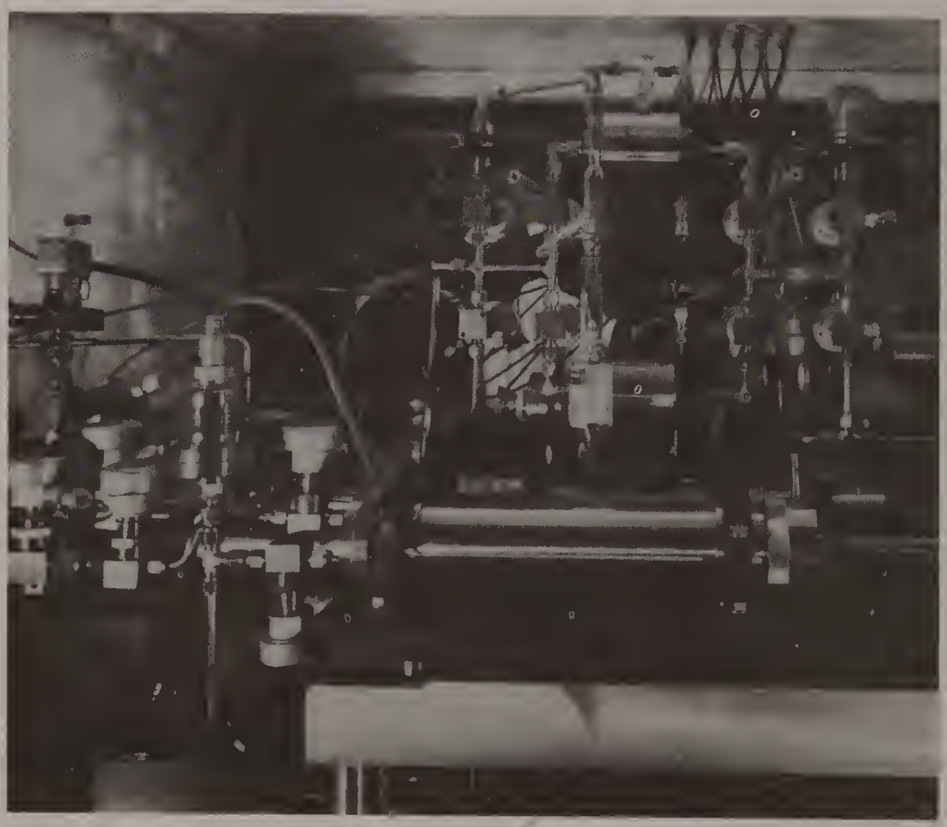
Incentives are needed for bold research to develop effective new drugs

Pharmaceutical research offers exciting prospects for new drug development, but industry may need encouragement and support to undertake innovative projects. That outlook was projected by Mr. F. P. Doyle at the 7th International Symposium on Medicinal Chemistry (held 2 - 5 September 1980 in Torremolinos, Spain). His paper "Medicinal Chemistry and Current Problems in Drug Development" was cited by Prof. J. Mathieu (IUPAC Representative at the conference) as one of the most significant presentations made to this IUPAC-sponsored symposium.

Mr. Doyle described how development of new drugs does not always result from the methodical efforts of chemists and pharmacologists to relate chemical structure with biological activity. In some cases, clinical pharmacologists have discovered that the "side-effects" of some compounds could be utilized to treat an entirely different disease. These later applications may prove more valuable than the drug's original function. For example, sulfonamide drugs were originally introduced to combat bacterial infections, but it was soon recognized that their diuretic action could be exploited for the treatment of hypertension. Development of nitrogen mustards as the first modern cancer agents (see "Chemicals & Cancer: Search for the magic bullet" in *Chemistry International,* No. 4, 1980) stemmed from the selective toxicity of these compounds towards rapidly-growing white blood cells, observed in soldiers suffering from mustard gas poisoning in World War I. Many other examples can be cited: the angina drug Propranolol became used for hypertension; the hypnotic Phenobarbitone was adapted for treatment of epilepsy; the local anaesthetic Lignocaine was found useful for treating irregular heartbeat.

Mr. Doyle points to remarkable progress in drug development in the last 50 years. In 1932, he notes, the British Pharmacopoeia contained just 36 synthetic drugs (including asprin, phenacetin and phenobarbitone), many of which had been available as synthetic organic chemicals for many years prior to their use in medicine. Today, the British Pharmacopoeia contains 600 drugs, the majority of which have been introduced during the last 20 years. The 1976 Merck Index (the medicinal chemists "bible") lists 9856 compounds with useful biological activity of importance to the drug industry. Such drugs and vaccines are largely responsible for the dramatic improvement in disease treatment and prevention, and the im-

Several new techniques now reaching maturity will help pharmaceutical researchers to design new drug molecules.



Radiolabelling of drug molecules allows researchers to study the metabolism of pharmaceutical compounds (with an apparatus such as shown on left). It will help researchers understand how drugs are broken down in the body after they exert their desired biological action. These studies may allow researchers to develop new drug compounds with very similar chemical structure and biological activity, but which are metabolized to less toxic products. Synthetic compounds with the proper configuration for the desired biological activity might be identified through computer-aided drug design, shown below (*photos courtesy of Prof. J. Mathieu*).

pressive reduction of infant mortality and increased life expectancy achieved in many countries over the last fifty years.

What about the future? Mr. Doyle foresees that "the prospects for discoveries by medicinal chemists are as good, if not better, today than they were 50 years ago, providing that we tackle the problem of drug design on a broad front . . . This will involve increasingly close cooperation between chemists, biologists, metabolic biochemists, clinical pharmacologists and clinicians, if we are to make the most effective use of the large sums of money that must be invested in this work." He notes that while some areas of therapy are now served effectively by available compounds (drugs for bacterial infec-

Drug for Third World is unforeseen offshoot of research programme

A drug originally developed as a treatment for hookworm appears to cure schistosomiasis (a disabling parasitic disease affecting at least 200 million people in developing countries) according to a report in *Chemical & Engineering News* (Sept. 1, 1980, p.25). The drug, called amoscante, is stated to be effective in a single dose against all strains of the disease, appears to have no adverse side effects, and is inexpensive to make. It has been tested on animals for 5 years, and permission has been requested to begin clinical trials in the USA. The Chinese government has reportedly sidestepped the lengthy US testing procedures and has already started using the drug on human patients.

tion, hypertension, general inflammatory conditions and local anaesthesia), there is an urgent need for effective compounds to treat or control rheumatoid arthritis, hardening of the arteries, post-surgical thrombosis, migraine, cancer, virus diseases and central nervous system disorders. But despite the exciting opportunities for drug development, and greatly accelerated communication of scientific information, serious problems threaten to stifle innovative research and drug development.

The time period required for drug development and testing has become longer and longer, increasing about four-fold in the last 20-years. The increasing time-scale and costs are at least partly due to the stringent testing requirements of government regulatory authorities. These were prompted by several disastrous incidents, in which widely-used drugs were found to have unknown dangerous effects. In 1956, deaths resulted from the use of sulfonamide elixirs containing di-ethyleneglycol as a solubilising agent. Several years later, administration of the anti-nausea drug thalidomide to pregnant mothers caused many deformed babies to be born. Many governments reacted by imposing regulations requiring thorough testing of new drugs before they could be marketed.

Development of a new drug, from its initial discovery to first unrestricted sale of the product, now usually takes 10 - 15 years. Consequently, most drugs discovered today will not be widely available to patients until 1990 - 1995. This time-lag will exert a major influence upon the types of research undertaken by pharmaceutical companies.

For one thing, it is difficult for drug companies to anticipate economic conditions and medical need 10 - 15 years in advance. The uncertainty is leading many pharmaceutical companies to steer their research towards short-term projects for which the clinical need is already well established. It discourages true innovation and entry into unexplored areas requiring long-term drug research.

The protracted period required to introduce a new drug erodes the protection from competition conferred by patents. By the time a new drug has been developed, tested and is ready to be sold, about half its patent lifetime will have elapsed. Another 5 years may elapse before the compound is widely accepted and used by the medical profession. Sales of the drug will likely be approaching its potential demand only when patent protection is about to expire. The company which developed the drug may have only a few years of profitable sales to recoup their investment, perhaps as much as US$60 million, before competitors can copy and sell the drug at low cost.

Unless pharmaceutical companies can be reasonably confident that they will recover their investment, they will be reluctant to undertake far-reaching, and expensive research programmes. The need for extension of patent life is becoming more widely recognized, and government action might follow in the major drug-producing countries. However, patent protection in many developing countries is reported to be ineffectual or non-existent, and might even be weakening further (see *Chemistry International,* No. 3, 1980, p. 9-11).

To be able to recover their development cost, drug companies have concentrated on those areas of medicine where there will be substantial demand for treatment and a profitable market. There is little incentive, Mr. Doyle points out, for companies to invest substantial sums to conduct research on tropical diseases such as leprosy, malaria, toxoplasmosis, or bilharzia. Nor do drug companies have an incentive to invest research funds on relatively rare "minority diseases" (like disseminated sclerosis, ulcerative colitis, Crohn's disease, bone diseases such as osteoporosis or muscular dystrophy), for which effective drugs could probably be developed. To encourage major development efforts in these areas may require some form of government support.

Mr Doyle ended his lecture on an optimistic note. He emphasized the enormous progress achieved by medicinal chemists and the pharmaceutical industry in the past. As Research Director at Beecham Pharmaceuticals in the UK (an IUPAC Company Associate, where he is the IUPAC "contact individual"), Mr. Doyle is well aware of important new techniques in biotechnology and chemistry becoming available to the pharmaceutical industry. What is needed, he feels, is the confidence and support of governments, the media and the public.

Simple tests provide accurate results for pesticide residue analysis

Monitoring of pesticide residues in foodstuffs and the environment is an essential part of modern agriculture. However, the analysis of pesticide residues in soil and food at the part-per-million level of concentration normally requires sophisticated methods and expensive instrumentation. These methods are generally not suitable for use in developing countries. There, the equipment would likely be prohibitively expensive, or (with poor service facilities) unworkable.

A survey of pesticide analytical methods reveals that, in some cases, simple techniques can provide results which are reliable and nearly as accurate as sophisticated methods. Such methods meet the needs of developing countries for screening purposes in food inspection and environmental control. They can also form the basis for new residue analysis laboratories in developing countries.

To illustrate the value of simple analytical methods that are suitable for pesticide analysis, the IUPAC Commission on Pesticide Chemistry has undertaken a project to examine the literature of pesticide residue analysis. The Commission sought analytical methods that are simple, selective in their response to particular types of pesticides, and which approach the accuracy and precision of existing methods based on gas-chromatography and high-pressure liquid chromatography. Only those methods not requiring expensive equipment, large volumes of solvents, or materials of higher purity than are commonly available were considered. The results of the project are contained in the report *Development and Evaluation of Simplified Approaches to Residue Analysis,* to be published in *Pure & Applied Chemistry.*

The report identifies Thin Layer Chromatography (TLC) as a simple but effective technique that can be applied to a wide range of insecticides, herbicides and fungicides. It is stated in the report that "TLC appears to be the most convenient procedure of screening and determining some classes or groups of pesticides in multiresidue analysis. TLC is simple, fast, sensitive and can be specific. It equals or even surpasses other techniques used in residue analysis with regard to speed and cost. It appears to be ideally suited to the needs of developing countries"

The advantages of TLC for the detection and identification of residues have long been recognized. Perhaps not widely realized is that semi-quantitative results can be obtained simply by looking at a developed TLC plate and estimating the relative size and intensity of spots. To improve accuracy, TLC plates can be examined with a double-beam densitometer. The development of such equipment during the last decade has so improved the accuracy that can be attained with TLC, that it now often compares favourably with more sophisticated techniques.

With thin layer chromatography, the separation and identification of components in plant and soil extracts is a basically simple procedure. A solution containing the pesticide is applied as a small "spot" at one end of the TLC plate (generally, a glass plate coated with alumina or silica gel adsorbent). That end of the plate is dipped into solvent solution. Capillary action causes the solvent to move along the adsorbent coating, flow past the spot, and displace pesticides and other compounds from their initial position. Each sample constituent moves only *part way* along the plate—a certain fraction (termed the "R_f value") of the distance travelled by the leading edge of the solvent. The distance travelled by each constituent varies, depending upon the "partition coefficient" of the adsorbent and the solvent used. This property is specific for that particular compound.

When the TLC is finished, the pesticide spot, if not coloured, must be visualized or made fluorescent by spraying the plate with chromogenic reagents. Generally, the reagent chosen is one that is selective for chlorinated hydrocarbons, organophosphorus compounds, or whatever the particular class of compounds to which the pesticide belongs. The identity of the pesticide is determined by comparing the position of its spot (R_f value) with that of a known standard applied to the same plate.

The exact TLC procedure is varied according to the properties of the particular pesticide. Slightly different solvent systems are recommended by various government agencies. In the United States, the Food & Drug Administration procedures are published in their "Pesticides Analytical Manual". Equivalent national procedures are published by the Canadian Department of National Health and Welfare, the Deutsche Forschungsgemeinschaft in the German Federal Republic, and by the State Commission for Pest, Plant Diseases and Weeds Control Chemicals of the Soviet Ministry of Agriculture.

Before pesticide extracts of foodstuffs or soil can be analyzed by TLC, a preliminary clean-up of the sample extract is often necessary. Oils and fats are particularly likely to interfere with the analysis, and have to be removed, which is usually accomplished with Fluorosil column chromatography.

Many precautions must be taken into consideration to obtain good results by TLC. Different brands of adsorbent frequently have different particle size or polarity, and should not be substituted in a procedure. In addition, standards should always be applied alongside the sample on the same TLC plate.

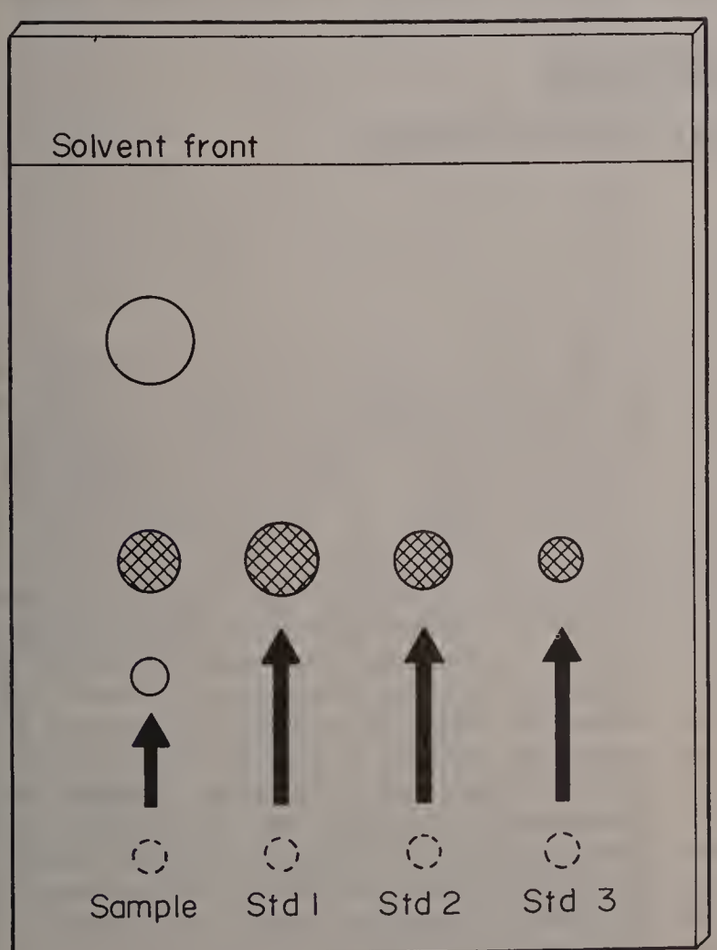
The most widely-used method for interpreting thin-layer chromatograms is by visual comparison of the location, size and colour intensity of spots. This method is sufficiently accurate and reliable for routine semi-quantitative screening methods and, surprisingly, it is more accurate than rigorous measurement of spot areas with a planimeter. To obtain good results, however, the analyst must devote particular attention to the precise application of samples on the TLC plate and uniform application of detection reagents. The use of precoated plates with a uniform layer of adsorbent improves the reproducibility and the resolution of spots.

For accurate results, it is necessary to evaluate the size and colour intensity of TLC spots by thin-layer densitometry. The densitometer can measure the absorbance, reflectance or fluorescence due to the pesticide in the TLC spot, and compute the total amount of pesticide present. When performed by an experienced analyst, this technique can reportedly provide highly reproducible results with a precision of 1-2%.

An alternative method, which is also suitable for accurate analysis, involves scraping the spot from the TLC plate after it has been developed. The adsorbent containing the pesticide is extracted with solvent, and the pesticide analyzed by standard microchemical analysis methods.

Thin layer chromatography is not, of course, suitable for detection, identification or quantitative analysis of all pesticides or their metabolites. In these cases, it may be possible to utilize other simple analysis methods. Among these are biological assays, which monitor the effect of the concentrated sample solution on live insects. Biological assays unfortunately are not specific but can be carried out very quickly. Dithiocarbamate fungicides can be analyzed quantitatively by a very simple procedure involving acid hydrolysis to liberate carbon disulfide, followed by distillation and colourimetric determination of CS_2.

The report *Development and Evaluation of Simplified Approaches to Residue Analysis* was prepared by four members of the IUPAC Commission on Pesticide Chemistry: Drs. V. Bátora (Research Institute of Agrochemical Technology, Czechoslovakia), S. LJ. Vitorovic (University of Belgrad, Yugoslavia), H. P. Their (Institute



Thin Layer Chromatography is a useful technique for monitoring pesticide content of samples and for semi-quantitative analysis. A sample, and standards containing various amounts of the pesticide, are "spotted" near one edge of the TLC plate with a micropipette. The plate is then "developed" by placing in a solvent solution.

Movement of the solvent along the plate by capillary action displaces the sample components from their initial position. Each sample constituent is, with the proper conditions, resolved and travels different distances along the plate. The pesticide is thus separated from other compounds in the sample, as shown in this idealized chromatogram. The plate is sprayed with a reagent solution to visualize the pesticide spots.

The size and depth of colour of the sample pesticide spot is compared with those of the standard solutions. This allows the amount of pesticide in the sample to be estimated. Although this method is remarkably simple, its accuracy is adequate for most pesticide residue analyses. When more accurate results are required, the relative amounts of pesticide in the sample and standard spots are measured by scanning the TLC plate with a densitometer.

of Food Chemistry, University of Munster, German Federal Republic), and M. A. Klisenko (All-Union Scientific Research Institute of Hygiene and Toxicology of Pesticides, USSR). Future work on this project will likely be carried out in collaboration with the "Action Programme for Development of Practical (Simple) Methods of Analysis of Contaminants in Food" established by the United Nations Food & Agriculture Organization (FAO) and World Health Organization (WHO).

Related to this project are two other activities of the IUPAC Pesticide Commission to help developing countries. One is the preparation of a manual for conducting pesticide residue trials. It discusses sampling of food and feed, good analytical practice, and interpretation of analytical data in relation to proposed maximum residue limits established by WHO/FAO. This project is a response to the urgent need for international harmonization of procedures for producing and evaluating pesticide residue data. The manual will be a source of reference for developing countries initiating pesticide control programmes and should be of value to all scientists and administrators engaged in pesticide residue work.

The second project considers improvements that will enable existing analytical methods to be carried out more rapidly and cheaply. This project, entitled "Improved Cost Effective Approaches to Residue Analysis", will concentrate on miniaturisation of clean-up procedures and the use of automated techniques, and compare the use of internal and external standards for evaluating pesticide recovery. This project will aid developing countries by reducing the amounts of solvents and chemicals used for each analysis.

Final drafts of the manual "Guidelines for the Production and Evaluation of Pesticide Residue Data" and the report "Improved Cost Effective Approaches to Residue Analysis" are expected to be complete in time to be submitted to the Commission at its next meeting (during the IUPAC General Assembly in August 1981).

At the recent meeting of the Pesticide Commission, in July 1980, its Chairman (Dr. P. C. Kearney of the US Department of Agriculture's Pesticide Degradation Laboratory) proposed a working plan for the Commission's activities during the next four years. An important feature of the plan is its goal to involve more pesticide chemists in IUPAC-member countries in future activities of the Commission. To achieve this goal, the Commission plans to establish an organizational framework including national delegates and pesticide chemists in every IUPAC member country. The Commission also plans to contact interested persons in all international and national organisations involved with pesticide usage, especially those from developing countries.

Catalyst activity is modified by presence of reacting molecules

Remarkable advances in surface science have enabled chemists to examine directly the elementary processes occurring on catalyst surfaces. This approach contrasts sharply with conventional studies treating the catalyst as a "black-box" by examining only the reactants going to the catalyst, and products coming from the catalyst. Now however, experimenters are able to probe directly the chemical processes occurring at the active catalyst site. Some interesting conclusions to emerge from this new approach were presented at the IUPAC-sponsored 7th International Congress on Catalysis (held June 30 - July 4 in Tokyo). Summarizing the highlights of the conference, Prof. Kenzi Tamaru and Makato Misono of Tokyo University point out to *Chemistry International* that catalysis chemistry is no longer to be regarded as a "secret art", but is now gaining the status of a "real science".

One of the most important realizations to develop—and a concept which Prof. Tamaru stressed in his plenary lecture at the conference—is that the properties of catalyst surfaces are (in many cases) remarkably different *in their working state* than the properties of clean catalyst surfaces.

It has been known for many years that some reactants, intermediates and reaction products are adsorbed on catalyst surfaces. Indeed, it was correctly thought that catalysts exert their effect by acting on reactants or reaction intermediates bound to their surface. However, Prof. Tamaru points to recent findings that show that it is *not* simply the *clean catalyst surface* acting upon adsorbed molecules. Rather, the active sites on the catalyst surface are influenced by adsorbed atoms and molecules. The composition of the catalyst surface is not only different from that of the bulk material,

but is also altered by chemical binding to adsorbed species. A molecule or molecular fragment that is bound to the catalyst surface is *not necessarily* a substrate upon which the catalyst is acting. Even if an adsorbed species covers most of the catalyst surface, it might not be a reaction intermediate. It might, nonetheless, have a significant effect on the reaction by modifying the action of the catalyst.

As an example, Prof. Tamaru cites one of the most fundamental catalysis reactions, the decomposition of ammonia. The reaction, which occurs at 600°C on a tungsten surface, produces nitrogen and hydrogen gas. Recent experimental evidence indicates that the catalyst surface is almost entirely covered by chemisorbed nitrogen. In fact, the amount of nitrogen bound to the surface *during the reaction* is considerably more than is adsorbed when the catalyst is simply exposed to the same pressure of nitrogen gas. This is because nitrogen is formed at the catalyst surface and remains there until it can escape—and there is a relatively slow process. Only when the adsorbed nitrogen does escape can more ammonia molecules contact the surface, decompose and produce more hydrogen (which is not absorbed on the surface) and nitrogen. Desorption of adsorbed nitrogen is thus the rate-determining step of the reaction.

Another example is provided by the Fischer - Tropsch reaction, now employed on a massive scale to produce synthetic motor fuel from coal gas in South Africa. A mixture of carbon monoxide and hydrogen produced by gasification of coal reacts on the surface of a catalyst to form liquid hydrocarbons. A variety of catalysts have been studied in an effort to enhance the yield of desired products. Ruthenium on a silica support is a good catalyst for synthesizing straight-chain hydrocarbons, and recent experiments have monitored the constituents present on the surface of the Ru/SiO_2 catalyst. These studies show that, during the Fischer - Tropsch reaction, the ruthenium surface is covered primarily by adsorbed carbon monoxide. To a much lesser extent, hydrocarbon reaction intermediates are also bound to the surface. These react with carbon monoxide and hydrogen (eliminating by-product water), extending the length of the hydrocarbon chain. The growth of hydrocarbon chains occurs only on a limited part of the ruthenium surface; most of the catalyst's active sites are covered by carbon monoxide. This does not mean that the CO-covered catalyst sites do not play a key role in the reaction.

On the contrary, the presence of carbon monoxide on the catalyst surface greatly influences its behavior. It exerts a marked effect, for example, in determining the outcome of other reactions catalyzed by the same catalyst. When carbon monoxide is present, no reaction occurs when saturated hydrocarbons and hydrogen (actually, the deuterium isotope) is passed over the ruthenium catalyst: the reactants simply appear unchanged at the exit of the reactor. In the absence of carbon monoxide, almost all the hydrocarbons are converted to methane.

Consequently, as Prof. Tamaru observes, previous studies which have investigated the surface of Fischer - Tropsch catalysts in the absence of carbon monoxide will have very little value in elucidating the mechanism of hydrocarbon synthesis in the Fischer - Tropsch reaction.

Studies aimed at making better Fischer - Tropsch catalysts are typical of the many applications for catalysis chemistry developing in the fields of energy conversion, utilization of natural resources and pollution control. A significant number of papers presented at the 7th International Congress on Catalysis were devoted to developments in these areas. While Prof. Tamaru (who is a member of the IUPAC Subcommittees on Catalysis and on the Chemical Physics of Surfaces) focussed on understanding the nature of the catalyst surface, others dealt with novel zeolite catalysts, in which the porous structure of the bulk catalyst performs a critical role in selecting those molecules which can reach active catalyst sites. These catalysts can dehydrate n-butanol without affecting isobutanol; or can discriminate in their action between linear and branched hydrocarbons. These are the first man-made catalysts to offer structural selectivity in their action.

In the past, man-made catalysts have been essentially "class selective". Hydrogenation catalysts, for example, will generally hydrogenate double bonds in any reactant molecule—regardless of the position of the double bond in the molecule, or which molecule contacts the catalysts. Now for the first time, there is a tangible prospect of man-made catalysts which approach the high structural selectivity of biological catalysts (enzymes). Whether this goal is a certainty or an illusion remains to be demonstrated, as no doubt it will in 1984, when the 8th International Congress on Catalysis is convened in Berlin.

Vinyl chloride: a submerged disaster is sighted and sunk

Although polyvinyl chloride (PVC) has been in use for a long time, far less is known about it than about comparatively new polyolefins. Until recently, the same was true of its safety. Through the 1960s, it was thought that the vinyl chloride monomer used to make PVC was practically harmless. Then in 1970, Prof. P. L. Viola reported to an international cancer congress that rats exposed to high concentrations of vinyl chloride had developed tumours. Further studies confirmed that vinyl chloride induced a rare form of liver cancer in rats exposed to vapour. These developments led investigators to suspect a possible hazard to humans exposed to vinyl chloride. It was soon discovered that long-term employees in several of the earliest PVC manufacturing plants had developed the same disease.

Based on these findings, a well-known cancer epidemiologist predicted that the cases of liver cancer just discovered among PVC workers would prove to be the "tip of the iceberg". He feared that, in view of the long latency periods required for cancer to develop, a massive epidemic of cancer would begin, reflecting the rapid expansion of PVC production in the previous decades.

Fortunately, the epidemic has not materialized. At the IUPAC—sponsored 3rd International Symposium on Polyvinyl Chloride (held in the USA on August 10 - 15, 1980), Jerome Heckman reported that "almost no new cases (of liver cancer among workers) have been discovered since the initial survey, despite the fact that increasing numbers of employees . . . had been exposed to vinyl chloride for as long as twenty years."

The predicted outbreak of chemically-induced cancer had apparently been averted by the prompt combined efforts of the PVC industry and concerned government agencies. The US Occupational Safety and Health Agency, OSHA, immediately set out to establish standards for the lowest feasible levels of vinyl chloride in the working environment. The agency adopted a maximum average exposure of 1 ppm, which essentially all PVC plants were able to meet.

Shortly after vinyl chloride was recognized as a hazard, the PVC industry began a research programme to explore methods by which the content of vinyl chloride in PVC products could be reduced. It was essential that no significant amounts escaped during storage, shipping, fabrication or use of the final product. The studies which followed, in the view of Dr. M. E. Carrega (IUPAC Representative at the Symposium), provide a striking example of how fundamental research can be applied to practical problems. Dr. Carrega, who is Secretary of the IUPAC Working Party on Structure & Properties of Commercial Polymers, cited as particularly significant the paper presented by A. R. Berens of the R&D Center of B. F. Goodrich (a major producer of PVC).

At the time that Goodrich started their research programme, virtually no data were available on the diffusion of organic vapours through rigid polymers. The researchers needed to develop new techniques. While vinyl chloride removal from PVC was the focus of initial research efforts, the techniques developed for these studies later proved to be valuable for investigating the structure of PVC—and other polymers. The diffusion of vinyl chloride in PVC was found to be typical of the behaviour of many small organic molecules within glassy amorphous polymers.

A major advance was made by diffusion studies on submicron-sized spherical PVC particles prepared by emulsion polymerization. Studies of PVC particles showed that nearly all residual vinyl chloride would diffuse to the surface and escape when particles less than 5 microns in diameter were heated for a few minutes at 100°C. For mass-polymerized or suspension-polymerized PVC resin, the escape of vinyl chloride monomer was limited by the presence of tightly agglomerated regions ("gels") greater than about 10 microns diameter held within the larger, porous polymer grains.

The rate at which residual monomer could be stripped from the resin could be greatly enhanced by producing resins with the minimum number of "gel" particles. Once this had been established, it proved possible to alter the manufacturing process and produce PVC resins that are virtually free of "gels". A stripping process was developed and perfected which could handle large quantities of such resins on a continuous basis. This stripping technology is now in general use. Dr. Berens summarizes in his paper that "The consistent, large-scale production of PVC with residual vinyl chloride monomer content of 1 ppm or less has now been achieved."

IUPAC conference sponsorship promotes free interaction among chemists

Recent upheavals in international relations have incited calls for the curtailment of scientific cooperation and exchange between countries with different political or ideological viewpoints. This is not new. There have been attempts to bar scientists from Israel, South Africa, USSR and USA (and very likely, many other countries) from attending international conferences. Bureaucratic obstacles to scientific communication are wielded as tools for applying political pressure against hostile governments, with individual scientists used as a fulcrum for the implementation of foreign policy.

The position of IUPAC is clear: countries hosting international chemistry conferences must allow *all* bona fide chemists to attend, participate, and relate with fellow scientists. This is a condition to which conference organizers must agree before IUPAC sponsorship is granted. IUPAC can—and does—exert considerable pressure to enforce this requirement when necessary. As a result, there is not one instance in recent years when a chemist (who complied with IUPAC recommendations regarding visa applications) was ultimately refused a visa to attend an IUPAC-sponsored conference. This is one reason why IUPAC sponsorship has become a label meaning free participation at scientific conferences, as well as a standard of technical excellence.

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I. IUPAC conference sponsorship

What does it mean?
What does it offer?

IUPAC sponsors 20 - 30 conferences each year. These encompass a wide range of subjects, but all concern chemistry and all must have international participation. As many delegates may be surprised to learn, IUPAC is not directly involved with the organization of most of these conferences. With a few important exceptions, IUPAC does not establish conference programmes (although it must approve them), does not publish brochures, or make arrangements for conference halls, hotels or dormitories. Yet, IUPAC sponsorship has very important implications for those who attend the conference, and those who organize it.

Of foremost importance is the freedom of participation implied by IUPAC sponsorship. This enhances attendance by delegates from many countries that probably wouldn't otherwise be represented. In particular, Eastern European chemists rarely attend Western conferences except those sponsored by IUPAC. This broad international participation allows the widest possible exchange of viewpoints and information.

When conference organizers apply for IUPAC sponsorship, they are asked to seek assurances from their government that all visa applications (submitted sufficiently well in advance) will be processed at least one month before the conference. Usually, communication with government representatives can be undertaken through the National Science Academy, National Committee for Chemistry, or Chemical Society which is the IUPAC member organization in that country. In addition, conference organizers should alert intending participants who need an entry visa to enter the host country, that they should apply three months in advance. The following notice should be published in all conference brochures:

> "IUPAC sponsorship implies that entry visas will be granted to all bona fide chemists, provided application is made not less than 3 months in advance. If a visa is not granted one month before the meeting, the IUPAC Secretariat should be notified without delay by the applicant."

Fortunately, it is rare that intending participants face refusal, though there may be delay in dealing with visa applications. But occasional instances do occur when a chemist wishing to attend an IUPAC-sponsored conference is not granted or promised a visa. If subsequent intervention by IUPAC fails to elicit a visa for a bona fide applicant, IUPAC would withdraw its sponsorship. In accordance with the procedure established by IUPAC (but so far, never invoked), the main invited lecturers would be notified of the reasons for withdrawal of sponsorship, and sponsorship of other meetings in the same country would be suspended until more favourable circumstances prevailed.

Most governments have responsed to IUPAC efforts to expedite the granting of visas. Only during one instance in 1976, when a South African applicant was unable to obtain a visa, was it necessary for IUPAC to actually withdraw sponsorship of a conference. Immediately afterward, the host country granted the visa and IUPAC sponsorship was promptly re-instated. Last year, visas were promised for two chemists only hours before the deadline for withdrawal of sponsorship (see discussion about the "Brobdig Incident"). Dramatic last-minute rescues, such as this, are not accepted as a normal way of handling such cases. Recent IUPAC policies dealing with early applications for sponsorship, and procedures established for a rapid response to these situations, should allow problems to be resolved at a very early stage.

The procedures developed by IUPAC have proven their effectiveness for attacking barriers to free participation at sponsored conferences. It allows the IUPAC President and Secretariat to respond quickly and decisively when there is need to do so. The procedures were endorsed by the International Council of Scientific Unions (ICSU) at their 15th General Assembly in September 1974. They had noted a number of cases in which bona fide scientists had been prevented from attending symposia sponsored by the 18 international scientific unions (of which IUPAC is one). ICSU urged all scientific unions to adopt the procedures developed by IUPAC, which they outlined in their brochure *The free circulation of scientists: Advice to organizers of international meetings.* It advises each scientific union to inform ICSU of any cases in which sponsorship had to be withdrawn. Each member union can then take this experience into account before granting sponsorship to other conferences in the same country.

As well as assuring free participation, IUPAC sponsorship also indicates that the conference will meet high scientific standards. In their application for IUPAC sponsorship, conference organizers are expected to provide a tentative list of invited lecturers. The application is referred to the appropriate IUPAC Division for evaluation. Each Division has its own criteria, but several general guidelines are suggested. While it is hoped that some lecturers will be recognized leaders in chemical research, increasing emphasis is placed on encouraging active young researchers to present conference lectures. In addition, greater participation of industrial chemists as conference lecturers is felt to be highly desirable.

One technique for achieving a balanced conference programme is to approach older well-recognized chemists, asking each to nominate a younger colleague to lecture in his field of expertise. It is suggested that no individual—no matter now prominent—should be re-invited to present plenary lectures at consecutive symposia in a series.

Some organizers accept as many contributed papers and posters as possible in order to increase the number of participants. This policy, in the view of IUPAC President Zollinger, may erode the quality of a conference by causing insufficient time to be devoted to each contributed paper and its discussion. In a recent circular letter to IUPAC Division Presidents, Prof. Zollinger recommended that at least 20 minutes be allocated for presentation of each lecture, and an additional 10 minutes for discussion. It is felt that meaningful discussion of specialized subjects is best carried out in poster sessions, instead of very brief lectures. Poster sessions must not be considered a medium for consignment of "third-class" papers. Abstracts of poster session papers should be included in the conference abstracts book. Compliance with these recommendations will in future be considered an important criterion in the granting of sponsorship. It is recognized, of course, that the organization of each conference must be tailored to suit its subject matter, and that a flexible approach is required in evaluating different types of conferences.

Another consideration is the cost of attending the conference. The expanding role of convention organizing companies and travel agencies in promoting "scientific tourism" is thought largely responsible for the swelling costs of conference registration, social events and accommodation. Practising chemists should clearly not be excluded by excessive costs from attending scientific symposia. IUPAC recommends that registration fees be kept to a minimum, and not be used to subsidize optional social events. Also, efforts to make available low-cost accommodation (usually, in university dormitories) are welcomed.

These recommendations are based largely on the personal experiences of IUPAC Officers. Some years ago, IUPAC Secretary General Ourisson attended a conference in Asia about which he reported that "we were housed at great expense in the most expensive hotel. No Asian participants could afford to have a room there. Also, the cost of the banquet was such as to make it a practically all-Western affair." He urged then that plenary lecturers be lodged in a hotel where they could have a chance of meeting delegates from all countries attending the conference. He also stressed that the cost of banquets and tours should not be included in conference registration fees.

To be granted IUPAC sponsorship, conferences must have international participation. The lecture programme must not be dominated by scientists from the host country. Plenary lectures should represent the broad spectrum of viewpoints and scientific thought prevailing in different countries. To ensure that the conference achieves an international character, it is suggested that the local organizing committee appoint an international advisory committee with expertise in the subject area. For some IUPAC-sponsored conferences, IUPAC Commissions serve as international advisory committees.

IUPAC sponsorship thus indicates to potential applicants that the conference will have both international participation and a high scientific standard. It is a label of quality that is widely recognized in the international chemical community.

To allow sufficient time for IUPAC sponsorship to be incorporated into conference brochures and advertising, conference organizers must apply for sponsorship *at least one year in advance* of the meeting—and preferably, two years in advance. This also allows enough time for IUPAC to disseminate information about the conference programme to member organizations so that announcements might be published in their national chemistry journals. The organizers are asked to provide 300 copies of their conference brochures for distribution to IUPAC member science academies and chemical societies, Company Associates, Associated Organizations, and prospective participants who address enquiries to the IUPAC Secretariat.

Besides the assurance of high scientific standard conveyed by IUPAC sponsorship, there are other important reasons why conference organizers apply for sponsorship. Sponsorship by IUPAC also provides a mechanism for publication of main conference lectures. The conference organizers are asked to appoint a Symposium Editor to collect papers of plenary lectures, usually 6 - 12 in number, and ensure that they are in suitable form for publication. The manuscripts of papers to be published need not simply re-state the content of the verbal lectures. It is suggested that manuscripts project a more comprehensive view of the subject, providing a critical survey of the field and giving pointers for the future, as well as describing the author's research results.

Conference papers are generally published in the official IUPAC journal *Pure & Applied Chemistry*. Rapid publication is achieved by reproducing the manuscripts directly from "camera-ready" laysheets provided by the lecturers. Plenary lectures of most conferences are now published within 3 - 6 months after the meeting, a period which is less than required by most other publishers. Lecturers are paid a fee of US$3/page to compensate for the extra care involved in preparing neatly-typed "camera-ready" manuscripts of their papers. Each plenary lecturer is also provided with a copy of the proceedings issue, and with 25 free reprints of his paper.

The world-wide distribution of *Pure & Applied Chemistry* ensures that material presented at IUPAC-sponsored conferences is easily accessible to chemists who did not attend the conference. The content of the journal encompasses a wide range of chemical subjects, consisting primarily of plenary lectures presented at IUPAC-sponsored conferences. No other chemistry journal can boast such a broad group of outstanding contributors selected from all countries of the world.

If the conference organizers wish to publish a large number of papers, or if the subject area is of particularly wide interest, IUPAC and its publisher (Pergamon Press) may decide to issue full proceedings as a separate hardcover book.

In some cases, conference organizers may have already made arrangements for publication of conference proceedings before submitting their application for IUPAC sponsorship. This does not necessarily mean that IUPAC sponsorship will not be granted, but IUPAC generally regards the publication of conference proceedings as an important consideration in the granting of sponsorship.

Once IUPAC sponsorship is granted, conference organizers may apply for financial assistance. A limited amount of funding is available for the few

conferences that are felt to be especially innovative and deserving of support. In granting funding, IUPAC favours conferences dealing with new and developing subject areas of chemistry, those which are not part of a well-established symposia series, and conferences located in developing countries or those distant from major technological centres.

When organizers apply for financial assistance, they are expected to provide a realistic budget listing sources of income, financial assistance and expenditures. IUPAC funding may be used to help offset travel and accommodation expenses of plenary lecturers, or for other valid scientific purposes; it is never to be used for social activities, which IUPAC feels should be financially self-supporting. Generally, financial assistance is available only for conferences held in alternate years (1982, 1984, etc) during which IUPAC does not incur the costs of its own General Assemblies.

An additional reason for conference organizers to seek IUPAC sponsorship is to exploit the experience accumulated during years of IUPAC sponsorship and publication of proceedings. As well as the successful innovations and serious mistakes observed by IUPAC representatives attending past conferences (see following description of conference chaos, and how to avoid it), considerable expertise has been gained by the close involvement of IUPAC in planning CHEMRAWN conferences (dealing with subjects in which CHEMical Research can be Applied to World Needs) and the IUPAC Congress (held every two years, and hosted by a member Chemical Society or Academy of Science). Based on the extensive experience of IUPAC Secretary General Guy Ourisson (in presenting conference lectures, and being bored, confused, or enthused by lectures of others), an article was prepared to guide lecturers in presenting lectures, slides and posters with maximum effectiveness and impact. Reprints of the article are provided to all organizers of IUPAC sponsored conferences. The article has been extremely popular, and many conference organizers have purchased and distributed copies to their lecturers. Since the initial publication of the article (in *Chemistry International,* No. 2, 1980), nearly *5000* reprints have been ordered.

II. Chaos at a conference, and how to avoid it

The evaluation of conferences for IUPAC sponsorship is based upon many years of experience working with conference organizers. Generally, sponsorship by IUPAC is a reliable indication that the conference will be well-planned, well-organized and well-run. The knowledge of mistakes made in the past, and consideration of how to avoid the same pitfalls in the future, are an important component of IUPAC experience. Nonetheless, major organizational blunders do occasionally still occur. One conference stands out in this respect, and provides valuable lessons that can help conference organizers steer clear of disasters lurking beneath the surface. Presented here is the confidential report of the frazzled IUPAC Representative at this conference, whom we shall here call Prof. Morrell.

Prof. Morrell asked *Chemistry International* not to divulge the identity of the conference or its organizers. To do so would prejudice subsequent conferences on the same topic, and this would be unfair and misleading. He points out that the conference organizers have recognized their mistakes and assembled an entirely new committee to organize subsequent conferences in the series. At the most recent conference, attended last year by Prof. Morrell (no doubt, with some hesitation), he found that "there was little I could have faulted them on". Therefore, Prof. Morrell's confidential report is presented here with fictitious names, dates and places substituted for those in the report. No similarity is intended to the names of real chemists or a real conference.

The 3rd International Conference on Putrefaction Chemistry was the most badly organized congress that I have ever attended and I think my criticisms should be placed on record because they may help other organizers avoiding similar blunders.

At a Chemical Society Meeting in London some three years ago, I was approached by Dr. H. Kleg, the Chairman of the Organizing Committee of the Putrefaction Conference, who invited me to be one of the three Honorary Presidents (together with Professor M. Oren, Israel, and Professor S. Lindelsk, Poland). Some two years later (July, 1976) I was phoned by Dr. C. Shepherd, asking for a summary of "My Plenary Lecture". This was the first time I had heard that they wanted me to lecture. Actually, it was inconvenient. Since 1970 I have given four Plenary lectures per annum in various parts of the world and in 1976 I actually presented six Plenary lectures. Accordingly, I was beginning to run out of material, especially as I already had three other Plenary lectures to deliver in 1977. However, I agreed to deliver this Plenary lecture. I had assumed that, as I was an Honorary President, this absolved me from any lecturing commitments; indeed neither of the other two Presidents gave lectures.

About three weeks before the start of the Symposium, Dr. Kleg wrote to me to inform me that Professor Oren would be absent owing to ill-health and that Professor Lindelsk had asked to be relieved of any duties as a Chairman because of his lack of command of English. He asked me if I would therefore chair the first three Plenary lectures at the Opening Ceremony. These were to be by Professor V. Gomez, Dr. E. Inglis and Professor N. Carling. I knew a little about Carling, less about Gomez and nothing about Inglis. Accordingly, I replied to Dr. Kleg, agreeing to

accept this further responsibility, but I asked him to let me have two or three lines on each speaker for purposes of introduction. I received a letter back saying he "knew as little about them as I did!" Hard luck.

A few days before the start of the Symposium, I phoned a friend whom I knew would be arriving the day before me, asking him to try to get some information for me on the lecturers.

When I registered about fifteen minutes before the Opening Ceremony, I was handed a screed on Professor Inglis written in abbreviated German (like a Who's Who entry). It was impossible for me to sort this out in the time at my disposal. Later I found that Professor Inglis was not a scientist but was Professor of "Futurology".

At the appointed time, Dr. Kleg climbed to the platform and welcomed the visitors. He gave a small opening speech and then descended. I knew that I was next, but as there was no Master of Ceremonies, and realising how disorganized they were, I waited to be told before I mounted the platform. Nobody had given me any instructions of any kind. Dr. Kleg came up to me and in a testy voice said "You must speak now". Several other messages were read out after mine. This Opening Ceremony was followed by a Coffee Interval and during this time one of my colleagues managed to find somebody who was able to give me the information I needed on Professor Inglis.

Shortly before the Plenary sessions started, Professor Lindelsk informed me that he had changed his mind and he would announce the first speaker (Professor Gomez). After this lecture I then introduced Professor Inglis who finished speaking fifteen minutes before the allotted time. He stepped down and I thanked him and then announced the next Plenary lecturer. A voice then called across "We are having fifteen minutes discussion", so I sat down. When this was over I made the following statement:

> "I note that tradition has been broken by holding a discussion after a Plenary lecture. The Organizing Committee seems to be intent on pursuing a policy by which its Honorary Presidents are kept in the dark; and so it is with some trepidation that I announce the next Plenary lecturer in case the Committee has arranged a further surprise packet for me."

I then introduced the next Plenary lecturer and the session went forward without further hitch. I was later told that Professor Inglis had only arrived at the Railway Station shortly before the lecture and on the way had insisted that there should be a discussion. He left the Symposium immediately after his lecture and the discussion had terminated.

I had been informed verbally that "a contribution would be made towards my expenses and this would be handed over during the Symposium". On the fourth day I was informed that the Committee had now changed its mind about contributing to the expenses of Plenary lecturers. If I had known this, I could have applied for support. At this stage it was too late and resulted in my being considerably out of pocket. The registration had cost me US$170!

The following privileges had been accorded. Registration was free. A free ticket had been pro-

vided for the Symposium Banquet and a free ticket for a Folk Lore evening. On the last evening a farewell buffet supper with dancing had been arranged. On the day before Professor Lindelsk and I were informed that a free ticket would be delivered to our hotels. Neither of us received such a ticket. When I attended the buffet supper a waiter collected tickets. I said to him that I was expecting to receive a ticket but it had not been delivered. Professor Kleg, who was nearby, shouted across "You must pay. Even I have to pay". So I did without further ado. I then checked with Professor Lindelsk and he had suffered the same humiliating experience, with the added complication that he had not enough money on him and had to borrow it.

A checklist to avoid disaster

While it is unusual for such a collection of blunders to be encountered at one conference, each of the events described by Prof. Morrell are look-alikes of oft-repeated mistakes. IUPAC Secretary General Ourisson described his experiences at one conference, during which he sat in the rear of a lecture room waiting for the last speaker to arrive for the closing ceremony. Prof. Ourisson passed the time and overcame his annoyance at the delay by conversing with a young lady chemist. When the ceremony finally did begin, Prof. Ourisson discovered that *he* was the missing speaker.

What can be learned from these embarrassing and exasperating incidents? Following his experience as Honorary President at the 3rd International Conference on Putrefaction Chemistry, Prof. Morrell suggested some simple precautions that could avert future misunderstandings and fiascos. Most of these recommendations, he points out, should be obvious. It is perhaps for this reason that there is a danger that they will be ignored.

Invitations
All invitations to Honorary Presidents, Plenary Lecturers or other special guests should be in writing. If the invitation is initially offered verbally or by telephone, it should be confirmed in writing.

Payment of Expenses
The invitation to conference lecturers should state clearly what contribution will be made towards expenses. Generally, the conference organizers should bear at least the cost of subsistence, registration, dinners and other general symposium expenses incurred by Plenary Lecturers and other guests. It is expected that travel costs to/from the conference would be paid as well. Whatever support is offered must be guaranteed.

Introducing Speakers
The Session Chairman should be supplied with a few lines suitable for introducing each speaker. It should be recognized that most lecturers want to get on with the job without delay. The introduction should never be long and biographical, should avoid eulogies or independent scientific discussion, and should enable the speaker to deliver his talk without delay or embarrassment.

Lecture Schedule
Plenary Lecturers should be informed in writing that they are expected to adhere to the time allotted. In addition, the Session Chairman must be asked to ensure that Plenary Lecturers finish on time. If signaling lights are used to indicate the end of the allotted time, the Chairman should be instructed how to control these devices, and the lecturers informed of their meaning.

Discussion after Lectures
It is not usual for discussion to follow Plenary Lectures. However, if this convention should be broken, it must be agreed in advance.

Briefing of Lecturers
All lecturers should be asked to present themselves 10-15 minutes before the start of their lecture (or lecture session). They should be instructed how to use the microphone, pointers, timing system, and how to call for slide changes. Lecturers using slides should be instructed beforehand to hand these over early enough for loading in the projector.

Language
The conference programme should state what language(s) will be permitted. Lecturers should state in advance what language they will use, and no deviations should be permitted.

Opening ceremonies
Some symposia organizers prefer to start immediately without any ceremony; others prefer a formal opening ceremony with messages of goodwill. Whichever system is followed, there must be a President or Master of Ceremonies. The same applies to any closing ceremonies. It is better for contributors to be sitting on the platform, if there is one, and they must be informed well beforehand that they are expected to give an address. Speakers should not be left squirming in anticipation, uncertain when they will deliver their address. Nor should others be expected to give an impromptu talk. In any case, the President or Master of Ceremonies must call each speaker by name to deliver his message.

Customs on how ceremonies are to be conducted and lecturers introduced differ from country to country. It would be foolish to adopt a blandish "international" style. IUPAC symposia should serve to introduce participants to the variety of mores and manners in existence throughout the world. But at the same time, conference organizers should provide explicit and clear information to participants (especially lecturers) so that they will not feel estranged by alien proceedings.

Banquets
In a few cases, conference organizers pride themselves in choosing such fine surroundings for their conference banquet that its expense essentially bars the participants, except those whose seat is paid by his organization or the symposium organizers. This should be avoided, and any reception should be accessible to most participants.

III. The Brobdig incident

It is IUPAC policy that no chemists should be blocked from entering any country to attend an international conference. This is a precondition of IUPAC sponsorship, and a principle on which IUPAC has acted decisively when freedom of participation has been threatened.

Nearly every year, there have been one or two instances in which applicants were obstructed from attending an IUPAC-sponsored conference by political authorities in the host country. In recent years, IUPAC initiatives have assisted conference organizers in influencing high-level government action. IUPAC has been able to successfully intervene in every case to ensure freedom of participation of all bona fide chemists at its sponsored symposia. The procedures developed by IUPAC have been endorsed by the International Council of Scientific Unions. They recommend adoption of the IUPAC procedures by their member scientific unions (which sponsor conferences in biochemistry, crystallography, pharmacology, physics and other scientific disciplines).

Presented here is an extract from the file of letters, telexes and telegrams concerning participation of two chemists at an IUPAC-sponsored conference held last year in Brobdig. Brobdig is a fictitious name. We have also altered the names, dates and other details that might allow the actual countries or individuals to be identified.

In late 1979, several chemists from Lillut had written to request information about the IUPAC-sponsored International Conference on Fluorescence Spectroscopy to be held in Brobdig in May 1980. There are no diplomatic relations between Brobdig and Lillut (both technologically-advanced countries), and in recent years, policies of the two governments have generally been antagonistic. Prof. Link, a Lillutian chemist, had written to the conference Chairman (Prof. Broden of Blefuscu University):

"On December 17th 1979, I submitted by air-mail a short communication to the Organizing Committee, and since then I have been looking forward to receiving a confirmation and a second circular. So far, I have not heard anything".

The IUPAC Secretariat was notified of this and other unsuccessful attempts by Prof. Link and Prof. Lister (another Lillutian chemist) to obtain information about the conference, visas to enter Brobdig, or even confirmation that the conference was to be held. It appeared that Brobdigian authorities had no intention of allowing Lillutian chemists to attend the fluorescence symposium.

On 16 April 1980, IUPAC Executive Secretary Dr. M. Williams cabled the Chairman of the Conference Organizing Committee, Prof. Broden.

IUPAC SPONSORSHIP GRANTED TO FLUORESCENCE SPECTROSCOPY CONFERENCE BY LETTER OF PRESIDENT PROF H ZOLLINGER DATED 11TH DECEMBER 1979 ON CONDITION THAT ENTRY VISAS WILL BE GRANTED TO ALL BONA FIDE CHEMISTS. IUPAC ADVISED THAT LILLUTIAN CHEMISTS HAVE NO REPLY FROM ORGANIZING COMMITTEE REGARDING THEIR PARTICIPATION IN SYMPOSIUM AND ACCEPTANCE FOR PRESENTATION OF THEIR PAPERS. PLEASE ADVISE SITUATION BY RETURN CABLE/TELEX OTHERWISE IUPAC SPONSORSHIP MAY HAVE TO BE WITHDRAWN.

Prof. Broden responded in a cable, received at the IUPAC Secretariat on 18th April 1980.

CONCERNING QUESTIONS MENTIONED IN YOUR CABLE, WOULD LIKE TO INFORM YOU ABOUT FOLLOWING. ORGANIZING COMMITTEE ALREADY HAS CONTACTED MINISTRY FOREIGN AFFAIRS BROBDIG CONCERNING PARTICIPATION MENTIONED BY YOU . . . DUE TO NATIONAL HOLIDAYS, THEIR ANSWER IS DELAYED. WE BELIEVE POSITIVE ANSWER WILL COME. AS SOON AS WE KNOW WILL CABLE IT TO YOU . . . WE WOULD VERY MUCH APPRECIATE YOUR WAITING OUR NEXT CABLE BEFORE MAKING ANY DECISIONS CONCERNING WITHDRAWAL.

Four days later, IUPAC telexed this response:

IUPAC PRESIDENT H. ZOLLINGER HAS RULED THAT UNLESS DEFINITE INFORMATION AVAILABLE IUPAC SECRETARIAT BY 25 APRIL REGARDING AT WHICH EMBASSY AND WHEN PROFS. LINK AND LISTER CAN GET THEIR VISAS TO PARTICIPATE FLUORESCENCE SPECTROSCOPY SYMPOSIUM, THEN IUPAC WILL IMMEDIATELY WITHDRAW ITS SPONSORSHIP AND ADVISE ALL INVITED LECTURERS OF THIS DECISION. ALSO SPONSORSHIP OF OTHER MEETINGS SCHEDULED FOR 1980 IN BROBDIG WILL BE WITHDRAWN UNTIL MORE SATISFACTORY CIRCUMSTANCES EXIST.

On April 25th, an urgent cable from Prof. Broden was received at the IUPAC Secretariat.

BROBDIG MINISTRY FOREIGN AFFAIRS GRANTED PARTICIPATION LILLUTIAN SCIENTISTS AT INTERNATIONAL FLUORESCENCE SPECTROSCOPY SYMPOSIUM. VISAS CAN BE RECEIVED PARIS OR VIENNA.

A subsequent urgent cable was received on 7 May.

ADDITION OF OUR CABLE FROM APRIL 25. INFORM YOU THAT COMMUNICATIONS OF PROFESSOR LINK INCLUDED PROGRAM AND PRINTED ABSTRACTS BOOK. HAVE RESERVED 40 MINUTES FOR PROFESSOR LISTER'S PLENARY LECTURE.

The IUPAC Secretariat notified Professors Link and Lister of these developments, and assisted in their arrangements for obtaining visas.

Prof. Link later wrote IUPAC of his experiences in travelling to the conference.

"I wish to inform you that I succeeded in getting to Brobdig in time to take part in the Symposium. I thank you for your efforts to ensure my participation, as well as for the information and instructions you kindly telexed to me."

"I had been unable to obtain any official confirmation whether I would get a visa at the Brobdigian embassy in Vienna. The information the day I decided to fly to Vienna was that the Brobdigian embassy was instructed to issue a visa for me, but not for my wife. I indicated in my preliminary registration, and also cabled later, that my wife will accompany me, otherwise I would not come."

"My wife and I showed up at the Brobdigian embassy in Vienna on May 14th. The consul had apparently been expecting us; while waiting he prepared our visas, permitting us (upon our request) to visit several cities along the way."

"In Brobdig, everything was fine and well organized. The personnel members assigned by the organizing committee have done their utmost to please every participant. As I understand from my wife, the ladies had a very enjoyable time."

"The International Fluorescence Symposium had a large number of participants, approximately 450 if I am not mistaken. The lectures were conducted in a spacious auditorium and lecture rooms provided with simultaneous translation. The posters were nicely displayed. There were (however) some barriers of communication with the Brobdigians, most of whom were accommodated in other hotels. We also had separate guided tours."

The conclusions to be drawn from this affair were considered by the IUPAC Executive Secretary. In a private letter, he wrote:

"It is now clear that IUPAC policy on entry visas was not made known by Brobdigian organizers to intending participants. For instance . . . the Second Circular received here on 27th April did not include any of the wording from our sponsorship letter. That may be because the organizers did not have time to include the IUPAC wording in the second printing."

"What have we learned from the Fluorescence Symposium? One thing for certain is that the IUPAC Secretariat has now set up a positive system which we are operating for all future IUPAC-sponsored symposia. It will ensure that organizers definitely include the officially requested IUPAC visas statement in their circulars to participants as early as possible. It has now been agreed that, except in very exceptional circumstances, IUPAC will not even consider granting its sponsorship unless application is received one year prior to an actual meeting. This should certainly allow sufficient time for our official visas wording to appear in the first and certainly second circulars from the organizers: the third circular is too late."

Microbes upgrade starch to high-protein foods

When the first International Conference on Chemistry and World Food Supplies* meets in one year's time, the development of entirely new types of foods is likely to be discussed. Perhaps most significant will be Single Cell Protein (SCP) as a substitute for meat and fish, and for protein-enrichment of bread, soups and other food products. SCP has already been used for animal feed for some years. Last July, a high-protein food based on microorganisms was cleared for sale by the British Ministry of Agriculture, Fisheries and Food. This represents an unprecedented development: the first time that an entirely new protein source has been cleared for human consumption by any Western government.

*CHEMRAWN II, to be held 2 - 5 February 1982 in Manila, the Philippines.

by Dr. Martin Gellender
Editor, Chemistry International

In the 1950's, researchers began to experiment with an entirely new type of foodstuff consisting of protein-rich bacterial cells. Initially petroleum was envisioned as the ideal source of carbon and energy for growth of edible bacterial mass. This material was termed "Single Cell Protein" since bacterial cells, unlike those of plants or animals, are essentially independent organisms.

The focus of much SCP development has now shifted away from the use of bacteria, and towards the utilization of moulds. The term "single cell protein" is generally extended to mould cells used for animal feedstuffs. For human foods, the generic term "mycoprotein" has been recommended by the UK Food Standards Committee, since this gives a more accurate indication of the origins of the protein. The cells of some moulds form branched strands (mycelia), as much as several centimetres in length. Along each strand, nutrients are transferred from cell-to-cell and each cell relies upon its neighbours for physical support. In this way, moulds resemble rudimentary multicellular organisms rather than independent "single cells".

Because of escalating costs of petroleum hydrocarbons, most SCP research programmes no longer concentrate on petroleum as a foodsource for microorganisms. One exception is a project underway in Kuwait to produce SCP from Liquefied Petroleum Gas, a byproduct of petroleum production. These hydrocarbons cannot readily be exported or used locally, but conversion to SCP would provide an indigenous supply of protein for livestock. Most SCP researchers, however, are now working with microorganisms that feed on methanol (made from surplus natural gas), starchy food products and residues.

Many varieties of bacteria and moulds have evolved to live with a wide range of nutrients, conditions and lifestyles. While some species cause food spoilage, or even food poisoning, others convert milk to cheese and yoghurt, leaven bread or ferment fruit juices to alcoholic beverages.

Even species with similar characteristics can have dramatically different dispositions. Of the many types of mushrooms (mould colonies), a few produce deadly toxins. Most mushrooms do not, and these are commonly eaten to enhance flavour and nutrition in many food recipes. With all bacterial or fungal food products, it is essential that only known and proven cultures of microorganisms be used. Conditions must be strictly controlled to prevent introduction of foreign strains.

Despite the great variation among bacteria and fungal species, there are several clear differences between these two types of microorganisms. Mould cells are much larger than bacteria, with a well-defined nucleus and cell wall. In comparison with bacteria, moulds grow slowly, doubling in mass about every 4 - 6 hours when provided with sufficient nutrients. This is much faster growth than most plant or animal cells can achieve, but much slower than is typical of bacteria (with a doubling time of about 20 minutes). Moulds prefer a slightly acid environment (pH 5 - 5.5), while most bacteria grow best in neutral solution. Finally, while some bacteria live in oxygen-free environments, all moulds need oxygen.

Many traditional food processing methods utilize bacteria and moulds to enhance the taste of food.

products. Even more important, fermentation can upgrade the nutritional value of foods. This, however, is often not recognized. When sugar is fermented to alcohol, for example, the yeasts enhance the vitamin, protein and essential amino acid content of the beverage. Indeed, beer and wine are an important source of nutrition for many people in the developing world whose diet is derived almost entirely from cereal grains.

During fermentation, microorganisms metabolize part of the solution's carbohydrate content into cell protein. Most fermentation products, and the microorganisms themselves, remain suspended in the beverage solution - and must *not* be filtered if their nutritional value is to be retained. Because of this suspended matter, many fermented native beers in the Third World (usually made from maize or sorghum) are cloudy in appearance and bear little resemblance to Western beverages. One example of an indigenous fermented food is tapé-ketella, an alcoholic food made from cassava tubers in Indonesia. Cassava itself contains only 1 - 2% protein, but the fermented product contains as much as 8% protein.

In the case of tempeh, a vegetarian meat analogue made from soybeans in Indonesia, the mould *Rhizopus* spp. actually comprises a significant fraction of the mass of the product, as well as a major part of its protein content. Tempeh is made from partially cooked, de-hulled soybeans. An initial bacterial acid fermentation increases the acidity of the beans to pH 5. This is favourable to subsequent growth of the mould but inhibits many bacteria that could cause spoilage of the tempeh. The fungal fermentation requires 1 - 3 days (depending upon temperature) and the mould strands knit the beans into a compact cake. The cake contains 42% protein (derived from the original soybeans and produced by the mould), and has a pleasant dough-like aroma. It has a mild flavour, and is generally dipped in sauce and fried, or cut into chunks as a meat replacement in soups. Other cereals, such as wheat, can be used in conjunction with soybeans to make a product that tastes like bread.

Much of tempeh's nutritional value and physical consistency is due to its content of mould. In this way tempeh might be viewed as a fore-runner of modern Single Cell Protein in the human diet.

Unlike these traditional fermentation-enriched food products, SCP consists *entirely* of bacterial or mould cells. So far, use of SCP has been limited almost entirely to cattle feed, rather than adapted as a staple in the human diet. In the UK, ICI's production of single cell protein animal feed (with the tradename "Pruteen") is projected to soon reach 60,000 tons/year. ICI is planning to expand production to 300,000 tons/year, utilizing a new species of microorganisms developed by recombinant DNA techniques. Both ICI processes use bacteria that feed on methanol. The Pekilo process, developed in Finland, produces an animal feed composed of mould fibres grown on spent sulfite liquor (a waste product of paper manufacture). Present plant capacity is 10,000 tons/year.

Two reasons are apparent for the bias towards development of SCP animal feed. Firstly, to introduce new food ingredients for human consumption requires extensive testing to prove the safety of the product. Western governments have become progressively more restrictive in the types of food colourants, preservatives and other additives that may be used. These are generally added to foods in very small amounts (well under 1%). By contrast, SCP would constitute the bulk of new food products, and would be an entirely new product never before consumed by any population. The rigorous testing programme demanded by government regulatory agencies serves as a formidable barrier, and has likely compelled many SCP researchers to concentrate on developing animal feeds, for which testing requirements are less stringent.

Another reason is the expanding interest in developing SCP as a *byproduct* to utilize a range of organic wastes. Such materials as rice straw, corn stalks and sugar cane waste would normally be burned, creating an air pollution nuisance. Cellulose waste, once hydrolyzed to starches and sugars, could be digested by bacteria or moulds and converted to a usable, saleable SCP product. So too might other organic wastes of the food processing or chemical industry—such as distillery slop, pineapple effluent and organic acids from coal gasification/liquefaction—prove an acceptable diet for SCP microorganisms. Indeed, the recent IUPAC-sponsored Fermentation Symposium (held July 1980 in Canada) gave the impression of a technological marketplace for those with expertise in SCP production, and those producing organic waste.

Only one group at the conference reported that they had embarked on a major research programme intended *exclusively* to investigate and develop an SCP product *for human consumption*. Dr. G. L. Solomons (Assistant Research Director at RHM, Ranks Hovis McDougall) explained that his company had—only 2 days before—obtained government clearance to sell their "mycoprotein" product in the UK. In his unscheduled lecture, Dr. Solomons described a 15 year effort to develop and test a microorganism which could be made to resemble chicken, ham and veal. Once their product is in commercial production, RHM expect to sell their meat analogues for prices competitive with conventional food products.

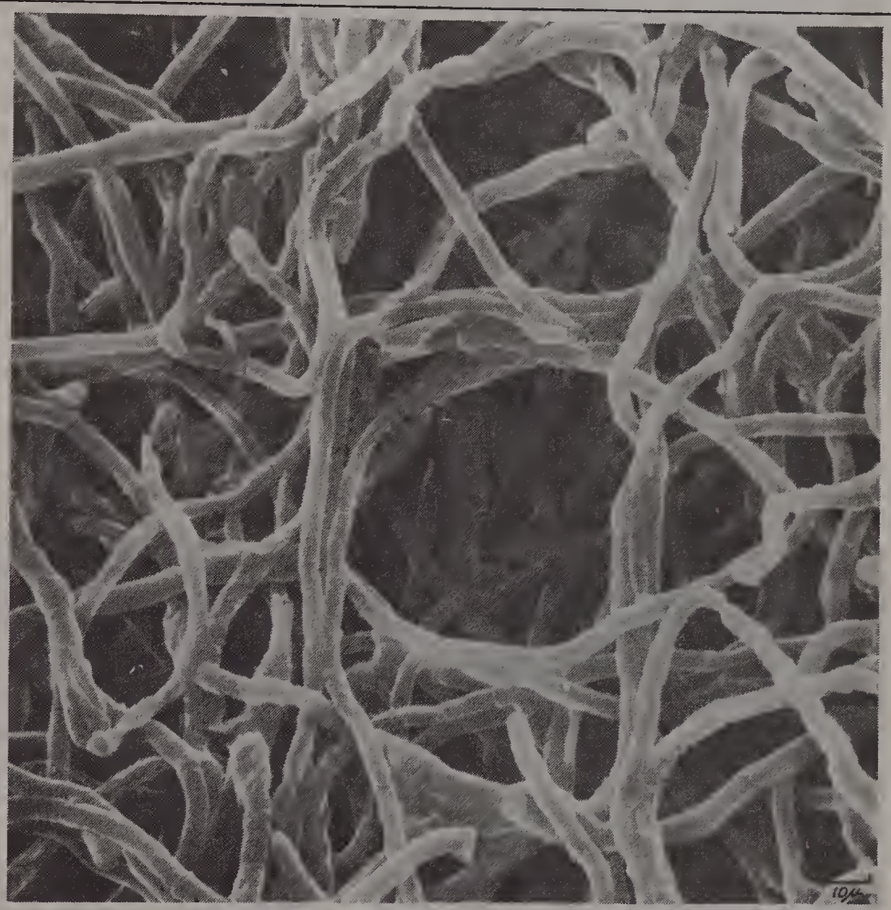
In developing high-protein fungal meat analogues, RHM knew that the physical consistency of their product was critically important for consumer acceptance. While pigs and livestock have apparently relished the mushy consistency of SCP animal feed, human consumers will certainly be more discriminating. At the very beginning of their development effort, RHM needed to select a microorganism which had a meat-like texture, as well as good nutritional value and absence of toxic components.

In 1968, RHM began their search for suitable moulds. They collected 3000 soil samples from around the world and isolated moulds that were able to metabolize glucose. Culturing each sample and isolating pure moulds was a tedious process, requiring as long as a year. Once isolated, most moulds were immediately rejected on the basis of their

growth characteristics, nutritive value, toxicity or consistency. Those remaining were subjected to increasingly rigorous testing until, in 1971, one mould was selected as having the best overall properties. By chance, it had originated from the 3rd soil sample, collected only about 6 km from the research laboratory in High Wycombe, the UK. It had been designated A3/5.

By itself, A3/5 is a virtually tasteless and odourless material, containing about 45% protein and 13% fat (dry basis). This composition is roughly comparable to grilled beef, with 66% protein and 30% fat. It might even be argued that A3/5 would be a more healthy component of the Western diet, because it has a lower fat content (mostly unsaturated) and 22% dietary fibre.

A3/5 can be prepared with a range of textures to simulate various meats and fish. By adding conventional flavouring agents, colouring agents and albumin binder, it can be made to look, taste, feel



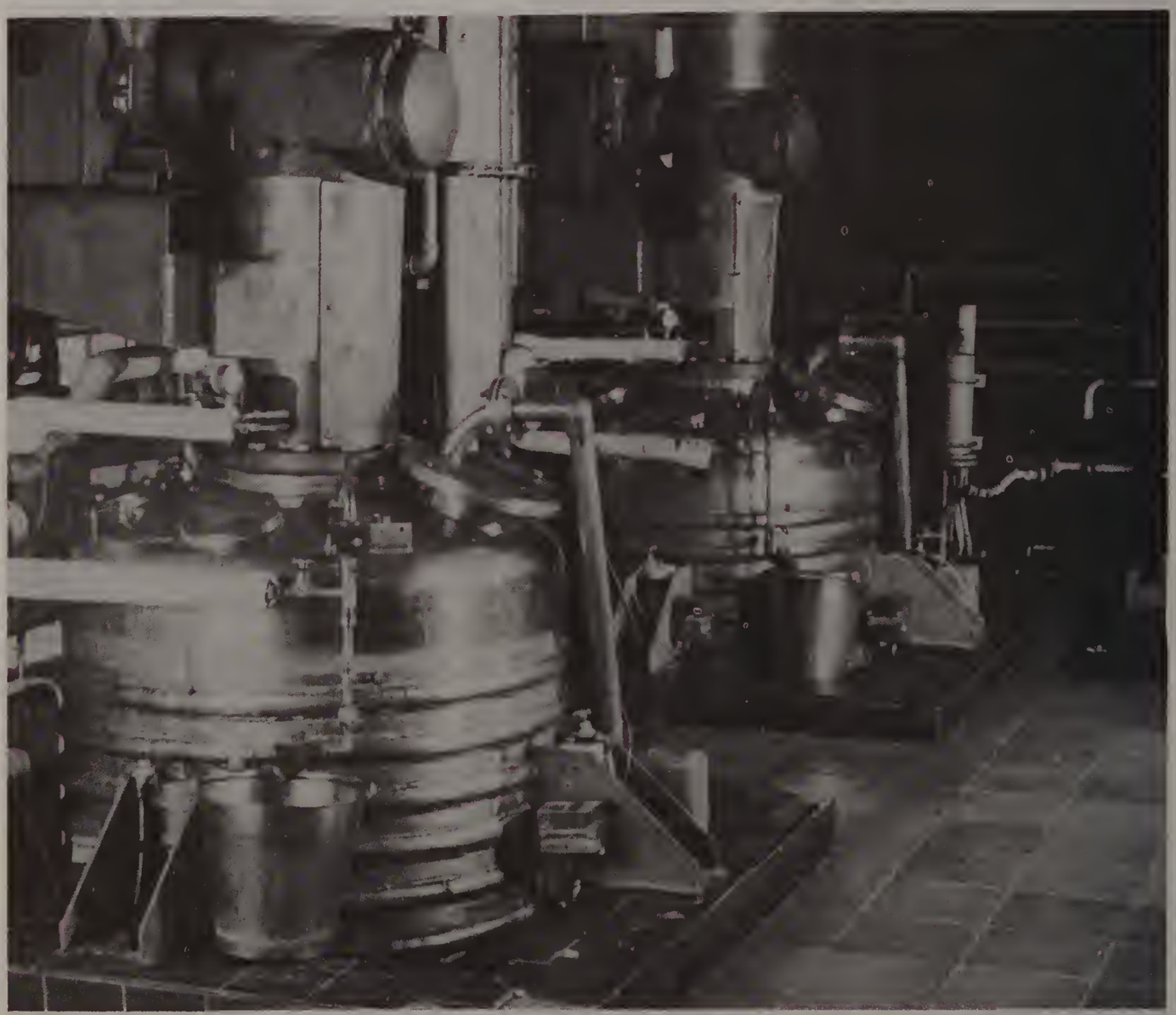
The fibrous structure of the A3/5 mould (shown right at 500X magnification) allows it to be formulated into food products with the texture of meat, like this "chicken croquette". During fermentation, mould cells rely on neighbouring cells along the mycelium fibres for physical support and transfer of nutrients. In this way, A3/5 mycoprotein bears little resemblance to bacteria grown as Single Cell Protein.

and chew exactly like chicken. It is, in fact, indistinguishable from chicken. Because it contains no bones or gristle, A3/5 chicken analogue is ideal for processed foods like chicken croquettes and meat pies.

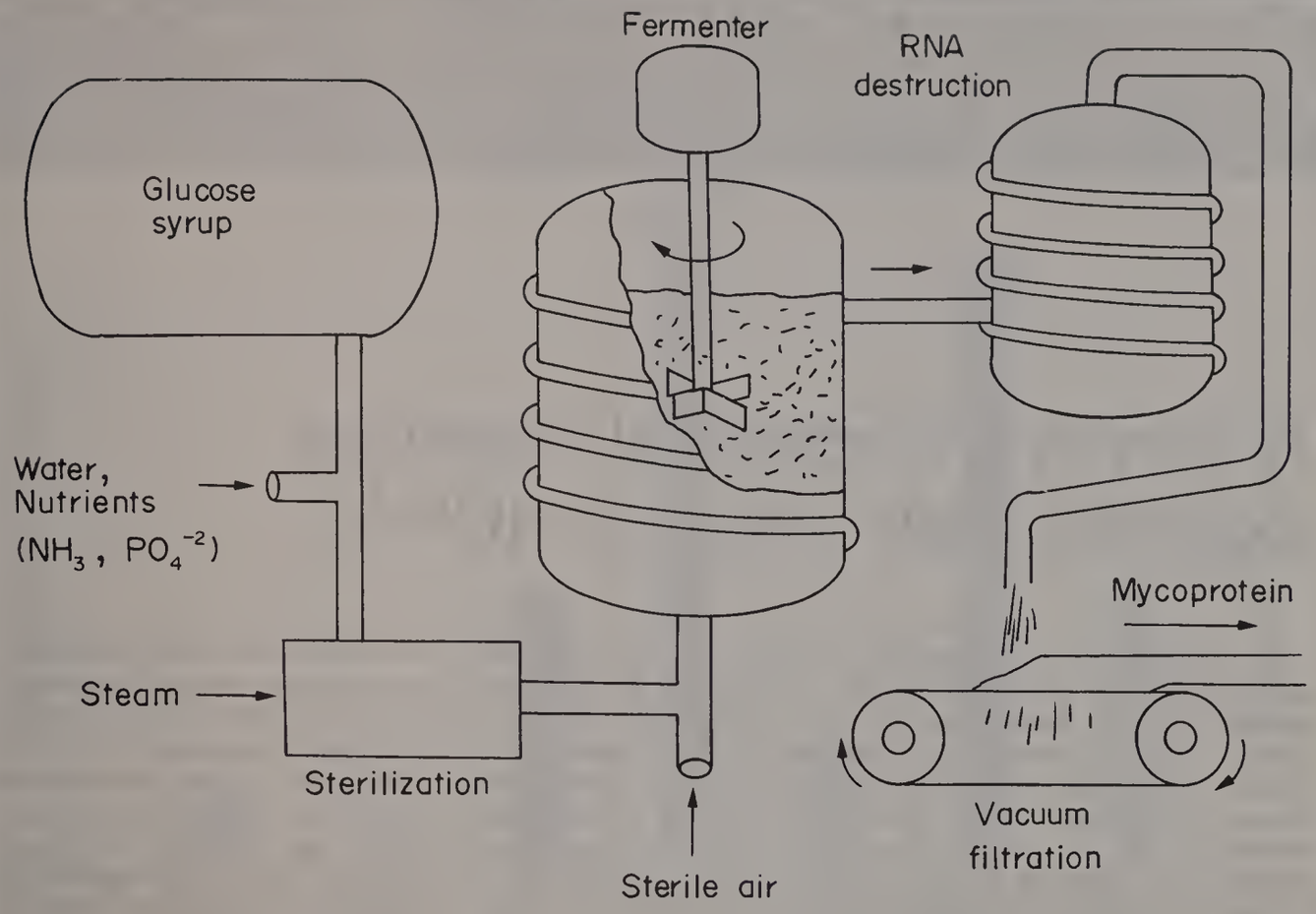
A3/5 is a remarkably versatile material. The length of the mould fibres can be controlled, allowing the texture to be varied. The pure mould has almost no taste, colour or odour, so a wide range of properties can be imparted with commercially-available flavouring and colouring agents. In addition to chicken, RHM have also formulated analogues for veal and ham. Lack of suitable flavouring agents has so far blocked the formulation of a satisfactory beef analogue. Nor are good flavouring agents available to simulate the taste of fish, but this limitation is sidestepped by mixing about equal parts of A3/5 and real fish in a breaded fish cake.

Although mycoprotein will initially be sold in the UK, applications in the developing world are obvious. Its production would provide a viable meat substitute for populations sustained on protein-deficient diets. The A3/5 mould converts each kilogram of carbohydrate (glucose from hydrolyzed vegetable starch) into 1080 grams of wet cell mass containing 136 grams of protein. This is several times as much as can be produced from the same mass of grain by livestock. From each kilogram of feed consumed, chickens produce only 240 grams meat (containing 49 grams protein). Even less efficient at converting carbohydrates to protein are pigs (providing 200 grams of pork, containing 41 grams protein) and cattle (producing 68 grams beef, with 14 grams protein).

The A3/5 mould is made with conventional fermentation and food processing equipment. Careful design and operating practice are required to prevent contamination by foreign microorganisms, as in all fermentation processes. The process begins with any source of food-grade starch (perhaps wheat or potato) that has been hydrolyzed into a glucose syrup. The concentration and nutrient composition of the solution is adjusted, and it is sterilized by heating before being pumped into the fermentation vessel. The fermenter is maintained at 30°C and is supplied with a continuous stream of sterile air. Fresh solution is continually fed into the reactor, and the mycoprotein-containing solution is continuously withdrawn. The rate of solution feeding/withdrawal determines the average residence time of the mould in the fermenter. The more time the mould is allowed to grow, the greater will be the length of its fibres and



RHM's pilot plant produces A3/5 mould in three 1300 litre fermenter vessels (of which two are shown here). The plant has been in operation for nearly a decade, providing mycoprotein mould for testing and formulation of food products. The plant will probably also provide mycoprotein for initial marketing trials of the new food products.



Glucose syrup (made from vegetable starch) is converted to high-protein meat analogues by fermentation of a *Fusarium graminearum* mould. Sterile feed solution is continuously pumped into the fermenter, ejecting the mould-containing solution. Subsequent heating kills the mould cells and destroys most of its RNA content. Mould fibres are then formed into a continuous sheet by vacuum filtration on a moving belt. Flavouring and colouring are added to the mycoprotein product before it is frozen and processed into foods. The filtrate solution, containing unconsumed nutrients and RNA breakdown products, might be utilized to produce a lower-grade SCP for animal feed.

the coarser will be its texture in the final product.

Upon leaving the fermenter, mould cells contain about 10% ribonucleic acids, which is too high for human consumption (the UN Food & Agriculture Organization recommends a maximum RNA content of 2%). The relatively high RNA content of moulds reflects their rapid metabolism and growth (compared with animal muscle cells, which comprise meat). However, the RNA content is reduced to about 1% by heating the mycoprotein-containing solution to 64°C for 20 minutes. Heating kills the mould cells and activates cell enzymes that degrade RNA into soluble products that diffuse from the cell. Then, the mould fibres are filtered; flavourings, binder and colouring are added; and the product is frozen. Alternatively, the mould may be spray-dried to a powder, to be added as a protein supplement in flour or instant soups.

Extensive testing has confirmed that A3/5 is safe and nutritious. The material was initially tested by feeding to several animal species, in some cases for periods spanning several generations. When no toxic effects were apparent in animal tests, two intensive trials were conducted with human volunteers at the Massachusetts Institute of Technology (USA). RHM has also conducted a less rigorous testing programme with local students and housewives. About 400 people have eaten A3/5 in these various trials, with one confirmed case of a mild adverse reaction. An occasional reaction such as this, points out Dr. Solomons, is to be expected even with conventional types of food.

At present, A3/5 production is limited to a pilot plant with three 1300 litre fermenter vessels. The capacity of this plant, about 100 tons/year, has been sufficient to complete testing and development, and will probably be sufficient for the first exploratory marketing efforts. After pursuing their development programme for 15 years, RHM will no doubt study the consumer market carefully before launching A3/5 products on supermarket shelves. No one knows how the British consumer, or consumers elsewhere, will react to this entirely new type of food. Many previous attempts to introduce high-technology or foreign food have failed. It remains to be seen whether A3/5 will become an accepted staple in the diet, or simply remain as another fungus among us.

A survey of industrial chemists explores their views on IUPAC

It is sometimes suggested that IUPAC places too much emphasis on *pure* chemistry and too little on *applied* chemistry. Indeed, Prof. G. Smets (former IUPAC President) cited this as a limitation of the present composition of the Union. "It seems to me", he stated in his address to the 1979 IUPAC General Assembly, "that the progressive amalgamation of academy and industry in many of our Commissions is highly desirable; it would meet some criticisms and questions about the utility of IUPAC for industry, especially when the economic situation is depressive." Precisely for this purpose—to establish industry/university contact and to favour their cross fertilization, a Standing Committee on Chemistry & Industry (COCI) had been formed within the previous two years. The functions of the new Committee, explained Prof. Smets, would be to inform IUPAC Company Associates of IUPAC programs, approach industry with enquiries about major chemical matters, and point out industrial needs in chemical science on which IUPAC might focus its attention.

To encourage greater industrial participation in IUPAC activities and continue the momentum gained during Prof. Smets' presidency, President Zollinger asked the Committee on Chemistry & Industry to evaluate IUPAC reports published during the period 1974 - 1980. Research directors of various chemical companies (IUPAC Company Associates in Czechoslavakia, Federal Republic of Germany, Israel, Italy, Sweden, Switzerland, and USA) were asked to evaluate each publication and provide a positive, negative or indifferent response. A rating of "no judgement" was applied when the participants were not familiar with the subject and unable to evaluate a report.

The survey results, and comments of the participants, reveal a number of options that might allow IUPAC to become more responsive to the needs of the chemical industry. However, the limited scope of the survey must be borne in mind when the results are interpreted. For one thing, the survey reflects the views of industrial chemists only: academic chemists might have a very different outlook. Furthermore, respondents conceded that their judgements were often based solely on the title of the reports or a superficial reading. Survey participants usually gave positive or indifferent responses: very few reports were rated negatively. Thus, the survey results seem to reflect the *relevance* of IUPAC reports to industrial chemistry, rather than a rigorous evaluation of their *quality*.

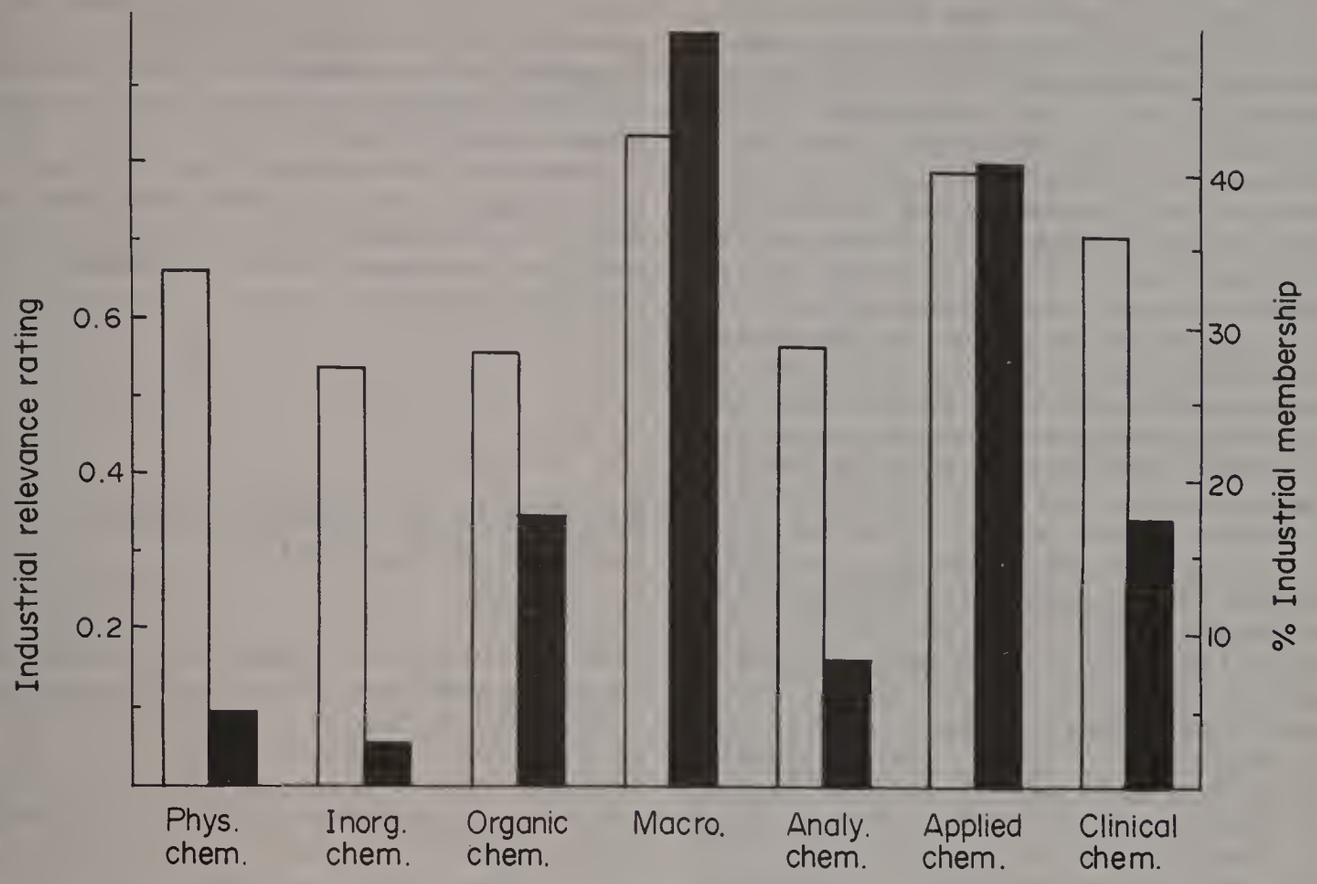
Despite these limitations, several observations become immediately apparent. Comments of the participants indicated that they regarded the reports favourably, but questioned the priority with which projects are undertaken. The participant representing a Swedish pharmaceutical company remarked, "The reports in general are of good quality and reflect an ambitious work". But he also noted that "the length of the reports vary from half a page to several hundred, and the length of the report does not always correlate with its content." The Research Director at a major US chemical company stated his "general impression that a lot of the papers dealt with subjects that need to be treated but are of limited importance. The job needs to be done; (but) are we applying the *minimum* time and effort to get the job done?"

In order to condense survey responses into a single meaningful index, *Chemistry International* compiled an "Industrial Relevance Rating" for the publications of each IUPAC Division. This rating reflects the relative approval, disapproval or indifference of all respondents. It disregards "no judgement" votes. The rate was defined so that a value of 1.0 would mean that all participants responded favourably to all publications of the Division; a value of 0.0 is equivalent to indifference by all participants. The rating is defined as:

$$\text{Relevance Rating} = \frac{(\text{no. positive responses} - \text{no. negative responses})}{\text{total positive, negative and indifferent responses}}$$

The highest Industrial Relevance Rating was earned by the Macromolecular Division. To many, this might come as no surprise. The Macromolecular Division was formed (in 1967) to integrate chemists from industry, universities, government laboratories and independent institutes in collaborative studies dealing with commercial polymers. It is the only IUPAC Division whose membership is composed very nearly of equal numbers of industrial and non-industrial chemists. It has two Commissions: one dealing with macromolecular nomenclature, and a second concerned with polymer characterization and

HOW DOES THE CHEMICAL INDUSTRY RATE IUPAC PUBLICATIONS?



Chemical companies in seven countries (a sampling of IUPAC Company Associates) were asked to evaluate recent publications of each IUPAC Division. Their responses were tabulated into an "Industrial Relevance Rating" (represented here by a white bar). A rating of 0.0 is equivalent to complete indifference to all publications; a rating of 1.0 would mean that all respondents replied positively to all publications of that Division.

Those IUPAC Divisions with the highest industrial rating, the Macromolecular and Applied Chemistry Divisions, also have a high proportion of industrial chemists among their members (represented by a black bar). Among the other Divisions, however, there is no clear correlation between the industrial rating and percentage of industrial chemists.

properties. Of this latter Commission, the Research Director of a major US chemical company wrote, "All of the subjects under this Commission (12 papers) are of interest to industry. This Commission gets top rating both on number (of reports) and subject (matter)." His views are reinforced by the Vice-president of Research & Development of another US chemical company. He wrote, "I believe the Macromolecular Division has done very well on the relevance of its activities to industrial interests. Also, participation by industrial members in the Macromolecular Division is significant. With respect to industrial participation, this Division could possibly be used as a model for some of the other Divisions."

The high industrial rating of the Macromolecular Division cannot simply be attributed to the high proportion of industrial chemists among its members. True, there is some correlation between the Industrial Relevance Rating of each Division and its industrial membership (see graph), but there are prominent anomalies. The Physical Chemistry Division has a slightly higher Industrial Relevance Rating than the Organic or Analytical Chemistry Divisions yet its complement of industrial chemists (4.7%) is considerably less than either of these Divisions. Despite these anomalies, Prof. Zollinger feels that all IUPAC Divisions and Commissions should strive to achieve a more equal balance of industrial and university chemists when new members are appointed.

The high rating of the Macromolecular Division might be partly due to its organizational structure, which is unique among IUPAC's seven Divisions. Attached to the Commission on Polymer Characterization and Properties are six Working Parties, each created for a specific task. The Working Parties deal with Molecular Characterization of Commercial Polymers, Structure and Properties of Commercial Polymers, Supported Polymer Films, Kinetic Parameters for Free Radical Polymerization, Surface Properties of Films and Fibres, and Thermal Properties of Polymers. The Chairman of each Working Party is a member of the parent Commission, so that a relatively small Commission is able

to coordinate the activities of about 120 polymer chemists. Perhaps this organizational structure, proposes Dr. G. Jäger (Secretary of the COCI Committee) could be adopted by other IUPAC Divisions.

Not all topics in polymer chemistry are suitable for the type of collaborative studies carried out by the Working Parties of the Macromolecular Division. For example, many polymerization studies are carried out with strict industrial secrecy. But, as Dr. Jack Barrett (Chairman of the Commission on Polymer Characterization and Structure) points out, basic work remains to be done in reaction kinetics which influence and control molecular characteristics of polymers, and all polymer manufacturers can benefit from progress in this field. Full molecular characterization of polymers also remains an essential need. In these areas, chemical companies and universities are receptive to collaborative research efforts undertaken under the auspices of IUPAC.

When a new subject area is identified and found to be suitable for a collaborative study, the IUPAC Macromolecular Commissions and Division Committee propose a draft outline for the project and select a leader. The Commission or Division Committee also consider if the project would best be implemented by a new Working Party or undertaken as a new project by an existing group. As the project gets underway, one or two workers collect the material for publication (usually in *Pure & Applied Chemistry*). Normally, Working Parties and project groups are self-financing, but a small amount of funds is allocated to provide reprints of published papers to all collaborators. To reduce costs to the collaborating organizations, regional groups are being developed in Eastern Europe, Japan and North America.

The Applied Chemistry Division earned the second highest Industrial Relevance Rating. The Division also has the second highest share of industrial members (41%). While reports of this Division were felt to be pertinent to the needs of the chemical industry, "there appears to be a real problem on priorities" in the view of one survey participant. Most of the Commissions in the Applied Chemistry Division, he explains, seem to restrict their activities to a few subject areas, leaving important topics untouched. "The Commission on Food Chemistry", he cited as one example, "had one paper on nitrosamines, one on single cell protein for animal feed, and eight papers on old subjects of limited interest. The Commission on Pesticide Chemistry had one paper on nitrosamines and nine papers on subjects at least 20 years old."

"On the other hand", the respondent continued, "the Commission on Reclamation of Solid Wastes had one publication (review papers presented at a Commission meeting), and one paper was published by the Commission on Atmospheric Environment. Is that a measure of the effort on these important subjects . . . or are they working on tough subjects that don't yield many papers? It is noteworthy that the Commissions on Photochemistry (in the Organic Chemistry Division) and Water Quality did not publish during this period, yet both are fields of high current interest."

To provide a sound basis for evaluating priorities of IUPAC Commissions, and to keep IUPAC Company Associates informed of Commission activities, this survey participant suggests that the Chairman of each Commission be asked to prepare a brief annual report. It would describe, on one page, key results achieved by the Commission. A second page would summarize the future objectives of the Commission and their significance. "Nobody likes to write reports, particularly one-page reports", the respondent admitted in his three-page letter. "However, I don't see any other way of knowing what IUPAC is doing and improving the program. . . There is a need for IUPAC, and I would like to see its programs improved and applauded."

Science in developing nations is stressed by ICSU

An increasing preoccupation with the use of science and technology in developing countries was evident at the 18th General Assembly of the International Council of Scientific Unions (ICSU), held September 1980 in Amsterdam. This trend was reflected in the election of new ICSU officers. The election of Prof. D. A. Bekoe, Vice-Chancellor of the University of Ghana, established a landmark: the first time that ICSU had selected a President from a developing country. Another unprecedented event was the election of an engineer, rather than a scientist, to an ICSU office. Prof. J.C.I. Dooge, Professor of Civil Engineering at the University of Dublin, was elected as Secretary General.

This change in leadership may presage a much broader outlook by ICSU. In his address to the ICSU General Assembly, Prof. Bekoe stated that "The main basis of our federation (ICSU) is to promote 'international scientific activity for the benefit of mankind': all other aims flow from this. It is therefore necessary that we bear this central objective in mind in all that we do. . . We are all aware, from our experience in the wide range of disciplines represented in ICSU . . . that it is difficult to state categorically which of our scientific activities will be of benefit to mankind. But this is the sort of value judgement that we have committed ourselves to (undertake), and which we need to make whenever it is possible to do so. With current speculation, in certain quarters, that ours may be the last generation of men and women on this planet, we dare not say, or even adopt the attitude, that development—economic and social development of mankind—is not our business."

The need for developing countries to expand their scientific and technological capabilities to solve their own problems is apparent from the Preliminary Report (of the Director General) on the ICSU medium-term plan for 1984 - 1989. It notes that, "According to a recent study, some 92% of the world's scientists and engineers engaged in research and development belong to these (scientifically advanced) countries, which number about 20. There is

still a considerable difference, therefore, between the level of their scientific and technological activities and that of the developing countries, in spite of efforts made by the latter."

"The quantitative results of policies (to develop national scientific capabilities) in the developing countries have been substantial. From 1974 to 1978, the average annual increase in the number of researchers—the best criterion of a country's scientific and technological level—was 9%, as compared with 3% in the developed countries. Qualitatively, the traditional difficulties of excessive compartmentalization between pure and applied research, the isolation of universities, and lack of concerted programming have in many cases been overcome. . . (Nonetheless) the limited availability of resources is overriding. At the end of the Second Development Decade, the figure of 0.5% of gross national product which was established as the proportion of national resources which the developing countries should aim to spend on science has not been achieved. The contribution which (these) countries can make through their own research efforts towards solving their own problems is liable not to increase relative to the research activities of the scientifically-advanced countries."

Teaching radiochemistry

Radiochemical techniques have become so well established that an introductory course in radiochemistry should be considered an essential part of the university chemistry curriculum. That is the view expressed by the IUPAC Commission on Analytical Radiochemistry and Nuclear Materials in their draft report *Teaching aspects of radioanalytical chemistry and analysis of nuclear material.* The report states that radiochemical analysis methods have become of comparable importance to optical, electrical and thermodynamic measurement techniques. Inclusion of a radiochemistry course in the undergraduate curriculum would allow students to consider and apply radiochemical methods in their postgraduate research.

The radiochemistry course should present basic nuclear physics and instrumentation, practical aspects of applied nuclear methods and applications in chemistry. Underlying physical principles (decay of radioactive nucleii, properties of radiation, measurement of nuclear radiation and radioactive materials) could be included as part of the course, or where feasible, presented in a preceding physics course. The Commission report recommends that the course emphasize those aspects of radiochemistry that apply most closely to the facilities and needs of the particular university and country. Furthermore, the report states that laboratory experiments should constitute a major part of the course so that students become acquainted with specific radiochemical techniques.

Further information on the Commission recommendations can be obtained from the author of the Report, Dr. de Bruin, Interuniversitair Reactor Institut, Mekelweg 15, Delft, Netherlands, or from Prof. F. Lux (Secretary, Commission on Analytical Chemistry & Nuclear Materials) Institut für Radiochemie der Technischen Universität Munchen, D-8046 Garching, Federal Republic of Germany.

Date and place are set for 1983 IUPAC General Assembly

The period 18 - 26 August 1983 has been proposed for the 32nd IUPAC General Assembly, to be held at the Danish Technical Highschool in Lyngby near Copenhagen, Denmark. The dates will be ratified at the next meeting of the IUPAC Council.

RECENT REPORTS

A study of impact strength testing and its relevance to real mouldings. Prepared by S. Turner for the Commission on Polymer Characterization and Properties. *Pure & Applied Chemistry,* 52, No. 12 (December 1980) pp. 2741-2763.

X-ray emission spectroscopy. Part IV, Nomenclature, symbols, units and their usage in spectrochemical analysis. Prepared by R. Jenkins for the Commission on Spectrochemical and Other Optical Procedures for Analysis. *Pure & Applied Chemistry,* 52, No. 11 (November 1980) pp. 2543-2552.

Recommendations for publication of papers on a new analytical method based on ion exchange or ion-exchange chromatography. Prepared by J. Inczédy for the Commission on Analytical Reactions and Reagents. *Pure & Applied Chemistry,* 52, No. 11 (November 1980) pp. 2555-2562.

Definition of persistence in pesticide chemistry. Prepared by R. Greenhalgh for the Commission on Pesticide Chemistry. *Pure & Applied Chemistry,* 52, No. 11 (November 1980) pp. 2565-2566.

A review of methods for the residue analysis of the systemic fungicides benomyl, carbendazim, thiophanate methyl and thiabendazole. Prepared by S. Gorbach for the Commission on Pesticide Chemistry. *Pure & Applied Chemistry,* 52, No. 11 (November 1980) pp. 2569-2590.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1981

TOXICOLOGY

March 4 - 7 Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142-144 Oxford Road, Cowley, Oxford OX4 2DZ, UK)

PARTICLE INTERACTIONS IN COLLOIDS

March 16 - 21 Int. Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, Australia 2600)

MÖSSBAUER EFFECT

April 13 - 17 Int. Conference on the Application of the Mössbauer Effect. Srinagar, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi, 110012, India)

PHOSPHORUS CHEMISTRY

June 1 - 5 Int. Conference on Phosphorus Chemistry. North Carolina, USA.
(Prof. Louis D. Quin, General Chairman, Paul M. Gross Chemical Laboratory, Duke University, Durham, NC 27706, USA)

SURFACE AND COLLOID SCIENCE

July 5 - 10 4th Int. Conference on Surface and Colloid Science, Jerusalem, Israel.
(Prof. A. S. Kertes, Institute of Chemistry, The Hebrew University, Israel-Jerusalem)

MACROMOLECULAR CHEMISTRY

July 6 - 9 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, 1er Étage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cedex 05, France)

POLYMER CHARACTERIZATION

July 13 - 17 Int. Symposium on Advances in Polymer Characterization. Durham, UK.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK)

CHARACTERIZATION OF POLYMERS BY NMR

July 20 - 23 22nd Prague Microsymposium on Characterization of Dynamic and Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlácek, Institute of Macromolecular Chemistry Czechoslovak Academy of Sciences, Heyrovského n.2, CS-162 06 Praha 616, Czechoslovakia)

CAROTENOIDS

July 26 - 31 6th Int. Symposium on Carotenoids. Liverpool, UK
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, POB 147, Liverpool L69 3BX, UK)

ORGANOMETALLIC CHEMISTRY

August 2 - 6 Int. Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, USA
(Dr. L. S. Hegedus, Dept. of Chemistry, Colorado State University, Fort Collins, CO 80523, USA)

CHEMICAL EDUCATION

August 9 - 14 6th Int. Conference on Chemical Education. Maryland, USA.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington DC 20550, USA)

ORGANOMETALLIC CHEMISTRY

August 9 - 14 10th Int. Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

PLASMA CHEMISTRY

August 10 - 14 5th Int. Symposium on Plasma Chemistry. Edinburgh, UK.
(Dr. B. Waldie, Chairman, Department of Chemical and Process Engineering, Heriot-Watt University, Chambers Street, Edinburgh EH1 1 HX, UK)

IUPAC CONGRESS

August 16 - 22 28th IUPAC Congress. Topics are: Chemistry applied to energy problems, environment, upgrading of resources, computers, analytical chemistry, physical chemistry, inorganic chemistry, organic chemistry. Vancouver, Canada.
(IUPAC Congress Secretariat, c/o Chemical Institute of Canada, 151, Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

ANALYTICAL STUDIES

August 20 - 21 Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford Street, London SE1 9NQ, UK)

HETEROCYCLIC CONGRESS

August 23 - 28 8th Int. Congress of Heterocyclic Chemistry. Graz, Austria.
(Prof. Dr. Thomas Kappe, Institute of Organic Chemistry, University of Graz, Heinrichstr. 28, A-8010 Graz, Austria)

DRUG RESEARCH

August 25 - 28 Int. Symposium on Strategy in Drug Research. Noordwijkerhout, The Netherlands.
(Symposium Secretary, Dr. M. L. de Winter, Philips Duphar B.V. POB 2, 1380 AA Weesp, The Netherlands)

AROMATIC COMPOUNDS

Aug. 30 - Sept. 4 4th Int. Symposium on Chemistry of Novel Aromatic Compounds. Jerusalem, Israel.
(Prof. I. Agranat, Dept. of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

ATOMIC SPECTROSCOPY

September 4 - 8 9th Int. Conference on Atomic Spectroscopy and 22nd Colloquium Spectroscopium Internationale. Tokyo, Japan.
(The Japan Society for Analytical Chemistry, 9th ICAS/22nd CSI, Gotanda Sanhaitsu, 26-2 Nishigotanda 1-chome, Shinagawa-ku, Tokyo 141, Japan)

CHEMICAL PHYSICS

Sept. 28 - Oct. 4 Int. Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-6, SU-117334 Moscow, USSR)

BIO-CALORIMETRY

Sept. - Oct. International Symposium on Bio-Calorimetry. Tbilissi, Georgian SSR, USSR.
(Dr. P. G. Asatiani, Institute of Physics, Acad. Sci. GSSR, Guramishvili str. 6, 380077, Tbilisi, USSR)

POLYMERIZATION OF HETEROCYCLES

Summer Int. Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.
(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, POB 49, Curie-Sklodowsjiej 34, PL-41 800 Zabrze, Poland)

NATURAL PRODUCTS

August 2 - 7 13th Int. Symposium on Chemistry of Natural Products. Pretoria, S.A.
(Mrs. Jeanne Beck, Symposium Secretariat - S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa)

COORDINATION CHEMISTRY

August 23 - 27 22nd Int. Conference on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010, Hungary)

MYCOTOXINS AND PHYCOTOXINS

Aug. 31 - Sept. 2 5th Int. IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Head, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30[2] DK-2100 Copenhagen 0, Denmark)

1982

CHEMISTRY RELATING TO AGRICULTURE

February 2 - 5 Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington D.C. 20036, USA)

SAFE USE OF SOLVENTS

March 23 - 27 Int. Symposium on the Safe Use of Solvents. Brighton, UK.
(Mr. S. G. Luxon, Health & Safety Executive, 25 Chapel Street, London NW1 4DT, UK)

CLINICAL CHEMISTRY

April 19 - 22 Int. Congress on Automation in Clinical Laboratory. Barcelona, Spain.
(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clinicos, C.S. "Principes de Espana", Hospitalet de Llobregat, Barcelona, Spain)

TRENDS IN PHYSICAL ORGANIC CHEMISTRY

July 11 - 16 6th IUPAC Conference on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Generale et Organique, Bâtiment Lavoisier 1 Place Louis Pasteur, 1348 Louvain-la-Neuve, Belgium)

MACROMOLECULES

July 12 - 16 IUPAC Macromolecular Symposium. Amherst, Mass., USA.
(James C. W. Chien, Dept. of Polymer Science & Engineering, University of Massachusetts, Amherst, MA 01003, USA)

COURSES

EXCITATION IN SOLIDS

15-29 June 1981. 5th Course of the International School of Atomic and Molecular Spectroscopy. This NATO Advanced Study Institute is intended for physicists and chemists at the post-doctoral level who have interest in solid state physics. Senior scientists in related fields and graduate students are encouraged to participate. The course will be held in Erice, Sicily.

The course programme will deal with the Quantum Mechanical Description of Solids, Recent Concepts in Solid State Theory, Phonons, Plasmons, Magnons, Exciton Physics, Excitons in Organic Molecular Crystals, Excitons in Semiconductors and Insulators, Polarons, Polaritons, Surface Excitations and Spectroscopy of Stoichiometric Laser Materials. Fifteen lectures from Belgium, Federal Republic of Germany, France, Italy, UK and USA will address the course.

Applicants must submit their application by April 10, 1981 to Prof. Di Bartolo, Department of Physics, Boston College, Chestnut Hill, Massachusetts 02167, USA. No special application form is required, but applicants should specify their date and place of birth, nationality, academic qualifications, present place of work and current research activities. They should also send a letter of recommendation from their research group leader, list of graduate courses (for graduate students), and list of publications (optional). The total course fee, including full board and lodging, is US$600.

OFF THE PRESS

Recent IUPAC publications

Organic synthesis— today and tomorrow

This book, containing 28 papers presented at the 3rd IUPAC Symposium on Organic Synthesis (held 15 - 20 June 1980 in Madison, Wisconsin, USA), presents a current overview of modern synthetic organic chemistry. Collectively, the lectures (including two by Nobel laureates) represent the state-of-the-art of organic synthesis and form a blueprint for research in the future.

The papers are grouped into three areas: (1) useful synthetic methods for general application, (2) new techniques for the construction of molecular subassemblies, and (3) the total synthesis of particular organic compounds. Of particular interest are papers describing the bio-organic chemistry of porphyrin metallocycles; the total synthesis of terpene and macrolide natural products; and new synthesis strategy using transition metals.

The 360 page volume, edited by Professors Barry M. Trost and C. Richard Hutchinson, is expected to be available in March at a cost of £40 (about US$90).

Organic sulfur chemistry

Organic compounds containing sulfur are gaining increasing use in industry, agriculture and medicine. Recent research in the chemistry of organic sulfur compounds, described at the 9th International Symposium on Organic Sulfur Chemistry (held 9-14 June 1980 in Riga, USSR), is presented in this volume. The fifteen papers cover the synthesis and reactions of organic sulfur compounds, determination of their structure and properties, the mechanisms of action and structure-function relationships of biologically active natural and synthetic organic sulfur compounds, and the identification and investigation of organic sulfur compounds in fossil fuels.

Containing about 270 pages and 700 references, the book is scheduled for publication in March. The cost will be about £33.50 or US$75.

THE LAST WORD

Caution: beware of Unnecessary Abbreviations (U.A.'s)

Is the language of chemistry becoming excessively cluttered with confusing abbreviations? Abbreviated terms may be advantageous for communication between scientists in the same field, but they contribute to the difficulties of communication between scientists working in different fields, as well as creating problems in teaching and abstracting. The proliferation of abbreviations, asserts IUPAC's Interdivisional Committee on Nomenclature and Symbols, has undesirable consequences and should be the concern of IUPAC.

In a short article *(Use of Abbreviations in the Chemical Literature,* Dr. David R. Lide Jr proposes that IUPAC nomenclature Commissions encourage authors and editors to reduce the number of abbreviations permitted in journals and textbooks. Those abbreviations that are used should be listed and defined in a single conspicuous place in each paper. To set an example, Dr. Lide (as associate member of the IUPAC Interdivisional Committee on Nomenclature & Symbols) urges that all IUPAC reports should follow this practice.

Of course, not all abbreviations are bad, and the *Use of Abbreviations in the Chemical Literature* sets the goal of eliminating only those abbreviations that are seriously ambiguous in their meaning, are based on incorrect use of language or grammar, or unnecessarily duplicate other abbreviations or symbols. It recommends that abbreviations which have become well-established in the chemical literature (like DNA and NMR) may be used, even without explanation. Other abbreviations are useful in a particular context or specialized journal, but are not well established in the general literature. Such abbreviations states Dr. Lide, should be defined in the paper in which they appear. Examples are FT for Fourier transform, AAS for atomic absorption spectroscopy, and TMS for tetramethylsilane.

The *Use of Abbreviations in the Chemical Literature* also provides a listing of current IUPAC recommendations about abbreviated terms and symbols in such subjects as analytical chemistry, thermal analysis, mass spectrometry, synthetic polymers and clinical chemistry. The article appears in the September 1980 issue (No. 9) of *Pure and Applied Chemistry.*

Chemistry International

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INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY (IUPAC)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

NATIONAL MEMBER ORGANIZATIONS

Academy of Scientific Research and Technology **(Arab Republic of Egypt)**
Asociación Química Argentina **(Argentina)**
Australian Academy of Science **(Australia)**
Verein Österreichischer Chemiker **(Austria)**
Comité National Belge de Chimie **(Belgium)**
Associação Brasileira de Química **(Brazil)**
Bulgarian Academy of Sciences **(Bulgaria)**
National Research Council of Canada **(Canada)**
Chinese Chemical Society, and Chemical Society located in Taipei, China **(China)**
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Det Kongelige Danske Videnskabernes Selskab **(Denmark)**
Suomen Kemian Seura **(Finland)**
Comité National Français de la Chimie **(France)**
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Science Council of Japan **(Japan)**
Koninklijke Nederlandse Chemische Vereniging **(Netherlands)**
Royal Sociey of New Zealand **(New Zealand)**
Norsk Kjemisk Selskap **(Norway)**
Polska Akademia Nauk **(Poland)**
Sociedade Portuguesa de Química **(Portugal)**
Korean Chemical Society **(Republic of Korea)**
Council for Scientific and Industrial Research **(Republic of South Africa)**
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Supreme Council of Sciences **(Syrian Arab Republic)**
Türkiye Kimya Dearneği **(Turkey)**
Academy of Sciences of USSR **(USSR)**
Royal Society **(United Kingdom)**
National Research Council, National Academy of Sciences **(USA)**
Instituto Venezolano de Investigaciones Científicas **(Venezuela)**
Unija Hemijskih Društava Jugoslavije **(Yugoslavia)**

Chemistry International

IUPAC

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Chemistry International

The news magazine of the International Union of Pure and Applied Chemistry (IUPAC)

SUFFERING FROM WRITER'S CRAMP? OUR FORMULA CAN MAKE TECHNICAL ARTICLES **FUN** TO WRITE, **INTERESTING** TO READ

1981 No.2 (April)

Pergamon Press

CHEMISTRY INTERNATIONAL

The news magazine of the International Union of Pure and Applied Chemistry (IUPAC)

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SUBSCRIPTIONS

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PROPOSALS FOR ARTICLES

Those wishing to write articles or propose topics for coverage in Chemistry International should write a brief letter to the Editor, explaining why the subject might be of wide interest or significance. Correspondence to the Editor should be sent to the IUPAC Secretariat, 2–3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.

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THE EDITOR'S DESK

Opinions expressed here are those of the author, and do not necessarily reflect the views or policy of IUPAC.

The hazards and benefits of being understood

Lack of communication between scientists and the public, and with other scientists, is a well-established tradition. Until very recent times, chemists were expected to be eccentric recluses who locked themselves into their laboratories and worked feverishly, emerging only after they had made a great discovery. Chemists have done little to dispel this image. Intelligence and skill were the virtues they sought in their colleagues, and tried to develop in themselves. The ability to be understood was not thought to be particularly important.

It might even be argued that this ability detracted from a scientist's prestige. If a chemist could explain his work so that it could be readily understood by others, each step standing out as a logical outcome of the preceding step, then it might appear that his research project required no special intelligence or skill. The individual would 'merely' be following the most reasonable and least difficult course.

Making reasonable decisions and avoiding experimental problems form the core of chemical research. Of course, the most reasonable and least difficult course is rarely apparent when a project is undertaken. At this point, intelligence, experience and skill are invaluable assets. When the project is brought to a point where conclusions may be reported, it is tempting to describe the difficulties and subtleties of the project. No doubt, promising ideas were pursued and lead nowhere, trying decisions were made, and repeated frustrating attempts were made to find the conditions needed for the experiment to work. The mission of the chemical researcher is to overcome these problems; but when writing a paper, his task is to make the results seem simple and their significance obvious.

The benefits to be gained by writing simply and clearly are considerable: to the reader, as well as the writer. The time and concentration of every researcher is taxed by dry, poorly-written articles that he feels compelled to read. Perhaps more serious is the attention not spent on articles whose real importance is shrouded by pages of complicated explanations, vague terms and discussion of peripheral details.

The chemical literature is cluttered with brilliant discoveries that died on the printed page, only to be rediscovered independently many years later. Particularly now, with the enormously increased number of chemical journals, publication of a theory or experimental result does not necessarily mean that it will be recognized or understood by other chemists.

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Scientific results should not simply be dumped into the chemical literature, to be microfilmed, indexed for computer storage, and catalogued for placement in library stacks. Published articles must be read. When a researcher obtains publishable results, he must be able to select essential information from years of work and data, present background information that others may need to understand the project, explain the material in the simplest possible way, and channel it to the people most likely to need this information.

Technical writing, like any basic laboratory skill, can be developed and refined. The special feature in this issue is intended to help improve your writing, and enjoy doing it. Reading this article does not guarantee you will become a prize-winning author, but with its guidance, you should be able to write what you mean, and mean what you write. And that is the most important requirement of a writer, and an essential skill of a scientist.

NEWS HIGHLIGHTS

Standard tests are evaluated for analyzing trace metals

In recent years, the hazards of exposure to certain nickel compounds have become widely recognized, as has the need for a reliable and generally acceptable method for analyzing nickel at trace levels in body fluids and tissues and in the environment. Nickel analysis at the part-per-billion level, however, is notoriously difficult because of contamination and blank problems, as the IUPAC Subcommittee on Environmental & Occupational Toxicology of Nickel related early last year in the report "Analytical Biochemistry of Nickel" *(Pure & Applied Chemistry,* 1980, *52,* 529-544).

In order to evaluate a provisional Reference Method for nickel analysis of serum and urine (based upon electrothermal atomic absorption spectrometry), the Subcommittee distributed ampoules of aqueous nickel solutions, urine and blood serum samples to laboratories in Japan, Canada, USA, England, France, Norway and Finland. The laboratories were asked to carry out four sets of analyses using the proposed Reference Method.

The results of the trial were presented at the 2nd International Conference on Nickel Toxicology, held 3 - 5 September 1980 in the UK. Drs. S. S. Brown, A. D. di Michiel and F. W. Sunderman Jr. presented data on analytical recovery, intra-laboratory and inter-laboratory precision and relative accuracy. The authors concluded that "In comparison to previous interlaboratory surveys, the results of the present test demonstrate substantial progress towards harmonization of nickel analysis of body fluids."

The IUPAC Commission on Toxicology, meeting in conjunction with the conference, was able to settle remaining technical details about the Reference Method (regarding the preparation of reagents, washing of plasticware and conditions of acid digestion) and approve its publication as a tested procedure for analysis of nickel in serum and urine. The method is presented in *Pure & Applied Chemistry,* March 1981, pages 773 - 781. The Subcommittee on Environmental & Occupational Toxicology of Nickel is now embarking on a project to extend the Reference Method to the analysis of nickel in whole blood and in tissue samples. The primary challenge is to develop a suitable technique for removing metals, notably iron, which are present in blood and body tissues in sufficient amounts to interfere with atomic absorption measurements of nickel.

In his foreword to the proceedings of the 2nd International Conference on Nickel Toxicology,* Dr. F. W. Sunderman Jr (Chairman of the Commission on Toxicology and of the Nickel Subcommittee) pointed to recent research findings which indicate that—in contrast to the toxic effects of nickel at high levels of exposure—it may serve a useful metabolic function in man and animals. No clear-cut biochemical role of nickel in animals has yet been identified, with the possible exception of one octopus species that incorporates nickel sulphide into pigment granules. However, Dr. Sunderman cited recent findings which indicate that nickel is an essential constituent of microbial urease and carbon monoxide dehydrogenase enzymes. Previously, nickel had been shown to be essential for enzyme activity of some plant ureases. Moreover, it has been

Adoption of standard chemical tests will be focus of international meeting

There is a growing awareness of the need to standardize analytical test methods, and provide a basis for comparing results obtained by different methods. Tests performed by various laboratories, each using their own test procedures, may provide widely different results for identical samples. Before a single test method can be recommended for universal use, collaborative studies must establish that accurate and reliable results can be obtained by participating laboratories in several countries. In recognition of the importance of such collaborative studies, an *International Symposium on Harmonization of Collaborative Analytical Studies* is to be held in Helsinki, Finland on 20 - 21 August (immediately preceding the 4th Euroanalysis Conference). The Symposium is being organized jointly by the IUPAC Divisions of Analytical, Applied and Clinical Chemistry.

The Symposium will consider the role and design of collaborative studies. Special emphasis will be placed on the comparison of analytical results, and the interpretation of accuracy, precision and reproducibility. The symposium will be of direct interest to organizations which sponsor collaborative analytical studies, and those who participate in such studies. National and international organisations involved in the development and use of standard methods are invited to send representatives to the symposium. Interested individuals are also invited to attend.

Contributions are invited from participating organizations or their representatives. A selection of papers presented to the symposium will subsequently be published in *Pure & Applied Chemistry*.

Preliminary registration forms are available from Dr. G. Svehla, Department of Chemistry, Queen's University, Belfast BT5 9AT, Northern Ireland. Summaries of contributed papers, not exceeding 350 words, should reach Dr. Svehla by May 31st.

established that nickel is an essential constituent of a coenzyme (F430) isolated from methane-producing bacteria. This co-enzyme is the first specific nickel-containing organic compound of low molecular mass that has been identified in biological materials.

In addition to efforts by the IUPAC Commission on Toxicology to standardize nickel analysis procedures, the Commission is expanding its activities with respect to other metals. The Commission's Subcommittee on the Environmental & Occupational Toxicology of Cadmium (Chairman, Dr. M. Stoeppler) has begun work on the analysis of cadmium in biological materials. The significance of cadmium as a toxic pollutant had remained largely unrecognized until quite recently, when potentially dangerous levels were discovered in food, water and soil in contaminated areas on three continents (see feature article in *IUPAC Information Bulletin,* 1979, No. 2).

Like nickel, cadmium poses a tricky analytical problem for the clinical chemist. Some of the intrinsic difficulties were revealed by a collaborative study in which the Subcommittee sent identical blood specimens to 25 laboratories in ten countries. Most of the participating laboratories were experienced in cadmium analysis by different methods, yet it was demonstrated that considerable improvements could be achieved in precision and relative accuracy. Most test results were consistent when blood samples containing about 5 parts-per-billion were analyzed, but some laboratories evidently had difficulty with background contamination. These analysis problems were pronounced when samples containing only 0.5 ppb were analyzed. In light of these findings, the Subcommittee will consider various methods used for cadmium analysis, and expects to choose three candidates to evaluate for a Provisional Reference Method. Accordingly, a further collaborative study is being planned by the Subcommittee.

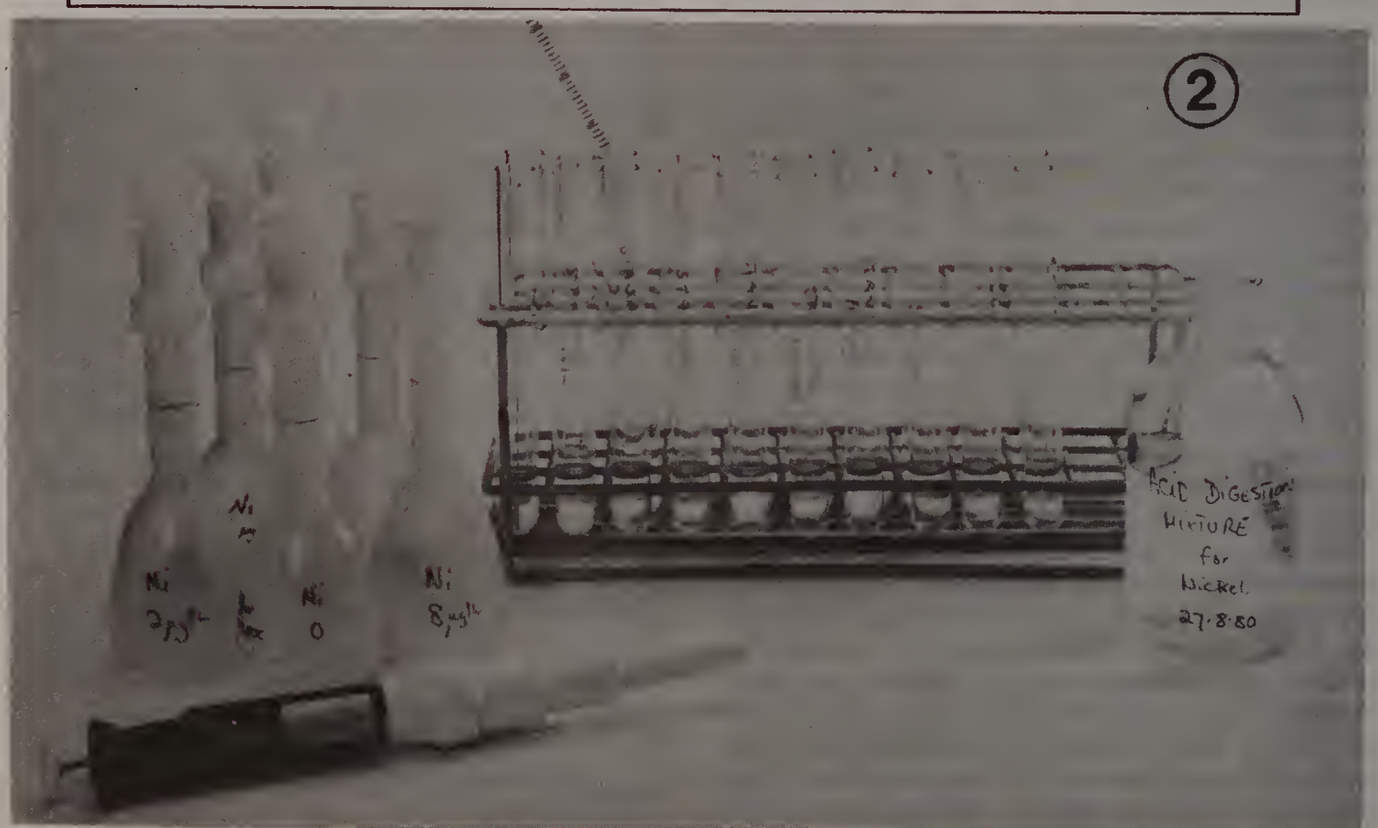
Meanwhile, the Commission on Toxicology has endorsed a proposal to form a new Subcommittee on Aluminium Toxicology. Aluminium is not normally considered to be a toxic metal, as it is rapidly excreted by the kidneys of healthy individuals. However, high concentrations of aluminium in local water supplies—especially where alum is used as a flocculating agent for water treatment—can be lethal to patients undergoing hemodialysis treatment for kidney failure (see Heavy metals: the good, the bad and the ugly in *Chemistry International,* 1980, No. 2, pp. 9-10). As its first project, the new Subcommittee will prepare a review of the "Analytical Biochemistry of Aluminium".

Based on its previous successful experience with the 1977 Symposium on Metal Toxicology, the Commission is now actively planning the 2nd International Symposium on Clinical Chemistry and Chemical Toxicology of Metals, to be held in Edinburgh, Scotland, 27 June—3 July 1982.

**Proceedings of the 2nd International Conference on Nickel Toxicology have just been published as a hardcover volume entitled "Nickel Toxicology" by Academic Press. The editors are S. S. Brown and F. W. Sunderman Jr. For more information, see IUPAC books "Off the Press" in this issue.*

Trace nickel analysis requires few main steps, but demands great care

To obtain consistent results for nickel concentrations in blood serum and urine, analysts should adhere closely to the experimental procedure described in the IUPAC Reference Method for Nickel Analysis. All glassware and plasticware must be scrupulously clean. Tubes, flasks and syringes to be used are repeatedly washed and rinsed, exposed to HCl fumes (1), and then rinsed again. Each sample and calibration solution is transferred into a digestion tube, to which is added a nitric/sulfuric/perchloric acid digestion mixture (2). The tubes are gradually heated to 300°C (3), allowing the digestion mixture to oxidize organic constituents. The residue is diluted with ultrapure water, and the pH is adjusted. A selective complexing agent for nickel, APDC, is added and the tubes mixed thoroughly (4). Then, the nickel complex is extracted into an organic solvent. Some of the nickel-containing organic layer is removed (5), and introduced into the carbon rod atomiser of an atomic absorption spectrophotometer (6). (*Photographs courtesy of Dr. Stanley Brown, Clinical Research Centre, UK*).



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International federation is still sought to aid collaboration in chemistry

A recent article in *Chemistry International,* (Issue No. 3, 1980, page 8) considered the formation of some type of international chemical society, and mentions a poll conducted by the American Chemical Society. The article states that the majority of respondents voiced opposition to the proposal. I would like to point out that this is not quite correct. The question addressed to the members of the American Chemical Society was, in effect, "Should the American Chemical Society *take the lead* in the formation of an International Chemical Society?"

About 16% of the Society's members responded to the questionnaire and about 42% of those responding replied in the positive. However, many of those who responded negatively indicated their strong support for the formation of some type of international chemical society and expressed the opinion that it should be done through IUPAC.

It is quite clear from the questionnaire that the majority of persons who responded to it are in favour of the formation of some sort of international chemical society, but they would prefer that the American Chemical Society not take the lead in its formation. Another result of the questionnaire is that the American Chemical Society has learned that about eight-thousand members are much interested in the formation of such an international chemical society. If the 42% positive vote could be considered to apply to the 118 000 ACS members, this corresponds to about 50,000 much interested members.

Prof. Glenn T. Seaborg
University of California
(former ACS President)

I notice in a brief article in *Chemistry International,* 1980, Number 3, page 8, that there is a Statement to the effect that "An International Chemical Society . . . appears unlikely to gain acceptance in the foreseeable future". In my capacity as Chairman of the Executive Committee of the Study Committee on the Formation of an International Chemical Society, I would like to point out that this statement is in error. Quite the contrary, a considerable amount of activity on the formation of some type of chemical society is underway.

The Executive Committee held its first meeting in Bangkok, Thailand in April in 1980, and has made several proposals concerning the mechanism and form which an international chemical society might take. The Committee will meet again in Costa Rica in February, 1981, will continue its discussions, and will attempt to identify the most practical and feasible proposal for the formation of some type of international chemical society, for presentation to the Full Study Committee on the Formation of an International Chemical Society at its next meeting in Yugoslavia in the summer of 1981.

The statement attributed to Dr. Eric Parker implying that a fairly clear indication of world opinion exists in opposition to the formation of some type of international chemical society is also in error. The Executive Committee of the Study Committee on the Formation of an International Chemical Society has come to the conclusion that most chemists and chemical organizations in developing nations are strongly in favor of the formation of some type of international chemical society. Further, the recent poll by the American Chemical Society indicates that there are several thousand chemists in the United States who are strongly in favor of the formation of such a society.

In the article in *Chemistry International,* mention is made of a letter to Chemical Society Presidents to the effect that international collaboration would be better served by building on existing institutions and, in particular, on the existing national chemical societies and on federations of these societies. The Executive Committee of the Study Committee on the Formation of an International Chemical Society is in agreement with this idea, and one of its proposals regarding the formation of an international body contains the concept of an international Confederation of Chemistry which would include all of the types of bodies mentioned in the cited letter.

It is the considered opinion of the Executive Committee that activity in this area is moving forward at a relatively fast pace, and it is its expectation that some type of international body including individual scientists in the field of chemistry will soon be a reality.

Simao Mathias, President
Sociedade Brasileira de Quimica

New chemical processes avert industrial mercury pollution

Among the most common chemicals used in industry on a large scale are chlorine and sodium hydroxide. Conventional technology for their manufacture is based upon mercury electrolysis cells, which release mercury into the environment. The environmental damage caused by mercury effluents of chlorine/alkali production plants was greater than previously suspected because of the formation of extremely toxic organic mercury compounds in rivers and lakes. Enormous areas of freshwater river systems have now been contaminated, as have wildlife that feed on fish. Formerly productive wildlife areas have been closed to fishing and native populations deprived of their livelihood.

In the last 10 years, the problem has been eased in some areas by mercury recovery from industrial waste effluents. Perhaps more significant, industry has been adopting technology which produces chlorine and alkali without the use of mercury. Wide-scale replacement of the mercury cell process, which has been undertaken in only a few countries, could be greatly expanded and accelerated by development of new types of mercury-free chloralkali cells. The possible operating and economic advantages of these new cells could motivate the chemical industry to finally abandon the mercury cell process completely.

Even if mercury emissions to the environment were to cease immediately, it had been thought, mercury concentrations in water and fish would remain near present levels for many years. Early monitoring results contradict this view. In Sweden, the content of mercury in fish from the Morrumson River has undergone a dramatic reduction from 6 ppm in 1967 to 1ppm in 1971 following the cessation of mercury discharges. Similar trends have been observed for many fish species in the St. Lawrence River during 1970-1975, and in Lake St. Clair (Canada) where mercury levels in 1977 had fallen to half those before controls on mercury discharges were imposed in 1970. These results suggest that mercury escapes from river sediments far more rapidly than was previously thought possible. They also indicate that environmental mercury contamination can be reversed fairly quickly by application of new emission-control technology and mercury-free manufacturing processes in the chemical industry.

by Prof. M. B. Hocking
University of Victoria, Canada

and Dr. Martin Gellender
Editor, Chemistry International

Until recently, mercury compounds were thought to be a danger only to a relatively small number of people working in certain industries or exposed to high concentrations by an accident. During the late 1960s, however, researchers discovered that mercury was widely distributed in river systems and coastal areas of industrialized countries, and that it could be present in fish in potentially dangerous amounts.

Contamination of fish, shellfish and wildlife is a consequence of the previously unsuspected behaviour of mercury in natural water systems. Instead of accumulating in sediments and remaining inaccessible and inert, as was supposed, mercury may be converted by natural chemical or biological processes into methylated compounds. Bacteria and chemical action in river sediments continually synthesize and destroy methylmercury, maintaining a state of equilibrium between inorganic mercury salts and methylated mercury. Methylmercury is far more toxic than inorganic mercury salts, and is far more readily absorbed into the bodies of fish, animals and man. Fish may concentrate methylmercury to 3000 times the concentration in the water; shellfish by as much as 100,000 times. Humans absorb over 90% of ingested methylmercury into their bodies, where it is

retained for a period of months before it is excreted. The damage it inflicts on the central nervous system is cumulative and mostly irreversible.

The first observations that mercury was accumulating in the food chain were made in Sweden in the early 1960's. Investigators studying mercury levels in birds were surprised to find that fish-eating birds contained high concentrations of the toxic metal. The mercury was found to be present in fish as methylated mercury compounds, although the source of contamination was traced to discharges of inorganic mercury salts by the paper industry (which used phenylmercury acetate as a slimicide) and by the chloralkali industry. It was not until 1967 - 1968 that Swedish scientists had sufficient confidence in their findings to report that the mercury in liquid wastes from chemical plants using mercury electrolysis cells was being converted to highly toxic methyl-mercury in the environment. The chloralkali industry was found to be a primary source of the mercury which was contaminating seafood and fish-consuming animals.

These findings prompted researchers to look for mercury contamination in other countries. In 1969, mercury contamination was discovered in the Saskatchewan River System and Lake St. Clair in Canada. The extent of the problem in Canada only became apparent when mercury levels in fish and animals were measured in various regions of the country. Even where fish were found to be grossly contaminated, mercury concentrations in the water were near the limit of detection by chemical analysis. In river water containing only 0.05 parts-per-billion of methylmercury, several edible fish species had concentrated mercury to one part-per-million, twice the maximum level permitted for seafood in Canada (and 20 times the maximum level recommended by the United Nations FAO/WHO for food items other than fish). For this reason, fish were found to be valuable indicators of mercury pollution. Mercury contamination of Canadian waterways was found to be widespread, and more than a dozen areas were officially closed to commercial fishing in 1970.

Canadian researchers also found that native populations, whose livelihood was based on fishing and hunting, were ingesting contaminated fish, seal and walrus. These native groups risked chronic poisoning if they continued to eat fish and fish-eating animals in contaminated areas, but were deprived of their livelihood if they stopped. Thus, mercury pollution was not simply a technological problem, but had acute social and political consequences.

Contamination of the affected areas resulted from industrial waste discharges, generally those of chloralkali plants. Chlorine and alkali production in mercury electrolysis cells was not the only source of mercury release into the environment—or even the predominant source—but it was the main threat to the environment.

Mercury preservatives and pigments in paints were previously the second largest use of mercury in Canada, but since the reduction in mercury consumption by the chloralkali industry, this has become the largest single use of mercury. Organic mercury compounds are added to paint at low levels (0.0005 - 0.06%) to avoid paint spoilage during storage and to retard mildew once the paint has been applied. Most of the mercury content of a paint film is gradually lost by evaporation. Its slow release into the air is not felt to cause a serious exposure problem. Eventually, nearly all the original mercury compound escapes into the atmosphere (where it has an average lifetime of 3 months) and is finally precipitated by rain. Dispersal of mercury in this way, with most reaching the ocean, eliminates any potential hazard. It can be calculated that total world production of mercury (10,000 tons/year) could not make any significant change in the mercury content of the oceans, estimated to be about 10^8 tons. But while man-made mercury emissions are not a hazard when dispersed in the oceans, they can cause pronounced effects when localized within lakes, river systems and coastal areas.

One significant source of environmental contamination may be mercury liberated by the smelting of sulfide ores of copper, gold, lead, silver and zinc. These ores normally contain traces of mercuric sulfide (typically, about 3 parts-per-million). However, the same processes used to concentrate ore for smelting also raise the concentration of mercuric sulfide by a factor of 40 - 50. One Canadian smelter, fitted with mercury emission control equipment, reported a mercury release to the atmosphere of 4.2 grams/ton zinc produced, and 1.95 grams/ton lead. A far more common situation is for smelters to operate without any control or monitoring of their mercury emissions. Most zinc/lead smelters probably emit at least twice this amount of mercury, and copper smelters may emit as much as 17 grams of mercury for each ton of metal they produce.

There is little doubt however that the main cause of mercury contamination of inland waterways, in Canada and other industrialized countries, has been the production of chlorine and sodium hydroxide—two of the most widely used chemical materials in the chemical and processing industry.

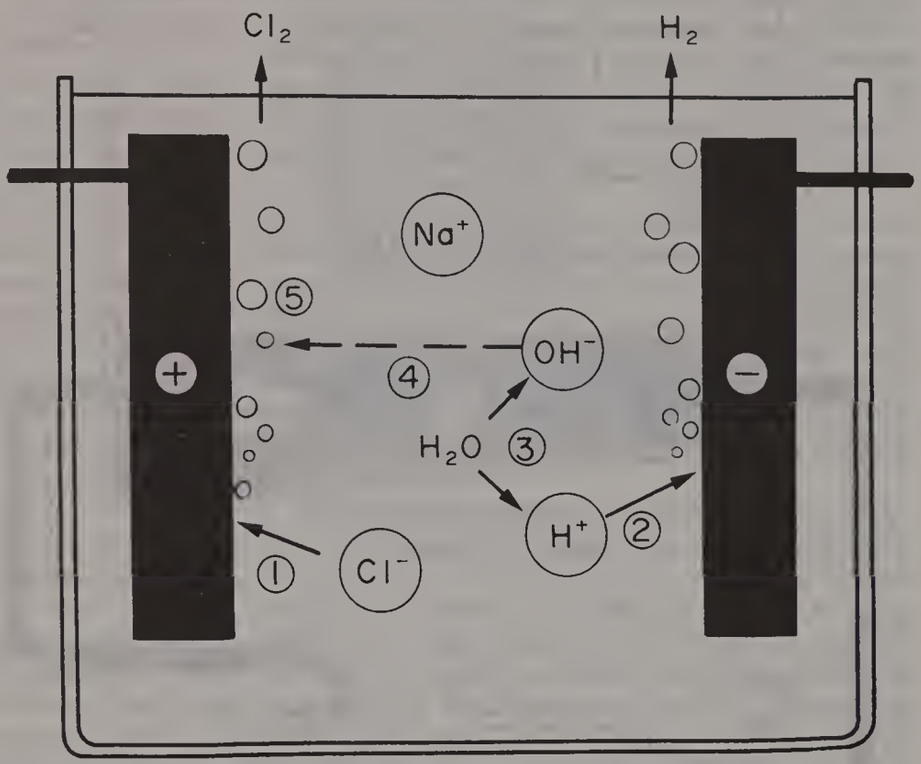
Chlorine and sodium hydroxide are generated simultaneously by the passage of an electric current through a concentrated brine solution (usually containing about 25% sodium chloride). In a simple electrolysis of salt solution, chlorine gas is produced at the anode, while the solution around the cathode becomes highly alkaline with sodium hydroxide (resulting from the electrolysis of hydrogen ions and the subsequent decomposition of water). Some measures must be taken to isolate the products formed at the two electrodes. Otherwise, hydroxide ions would migrate towards the anode (indeed, hydroxide *or* sodium ions *must* flow in order to maintain the electric current), react with dissolved chlorine, and produce sodium chlorate. In fact, this is the very method by which sodium hypochlorite and sodium chlorate are produced commercially. To produce sodium hydroxide, however, hydroxide ions must be prevented from approaching the anode and reacting with chlorine.

The mercury electrolysis cell achieves this separation of products by initially forming an entirely different product at the cathode—sodium metal. Once formed, the sodium immediately dissolves in the shallow pool of liquid mercury comprising the cathode of the electrolysis cell. Formation of sodium amalgam, a mercury alloy, prevents the sodium from reacting with the water of the salt solution and forming NaOH and

In a simple electrolysis of brine (NaCl solution), chloride ions are oxidized to chlorine gas at the anode (1). At the same time, hydrogen ions are removed from solution at the cathode and reduced to hydrogen gas (2). Replacement of the hydrogen ions by the decomposition of water generates hydroxide ions (3).

$H_2O \longrightarrow H^+ + OH^-$

The electrical current to the electrodes can only be maintained if an ion current is carried through the cell, dissipating the build-up of negative charge (hydroxide ions) at the cathode and positive charge at the anode (resulting from removal of chloride ions). To carry an ion current, sodium ions can migrate towards the cathode or hydroxide ions towards the anode. Unless migration of hydroxide ions towards the anode (4) is prevented, the hydroxide ions react with dissolved chlorine forming sodium hypochlorite, and ultimately sodium chlorate (5).



$2NaOH + Cl_2 \longrightarrow NaClO + NaCl + H_2O$

$NaClO + 2NaClO \longrightarrow NaClO_3 + 2NaCl$

hydrogen. *That* reaction is carried out later, with pure water, in an entirely separate 'decomposer' unit.

To electrolyze sodium requires a substantially higher voltage, 0.94 volts higher, than is needed to electrolyze hydrogen gas. The mercury cell is only able to produce sodium at all because of the high overpotential needed to liberate hydrogen on a mercury electrode. Impurities in the mercury or the brine must be avoided, as even trace amounts of certain metals can cause release of hydrogen into the chlorine product, forming a highly explosive mixture.

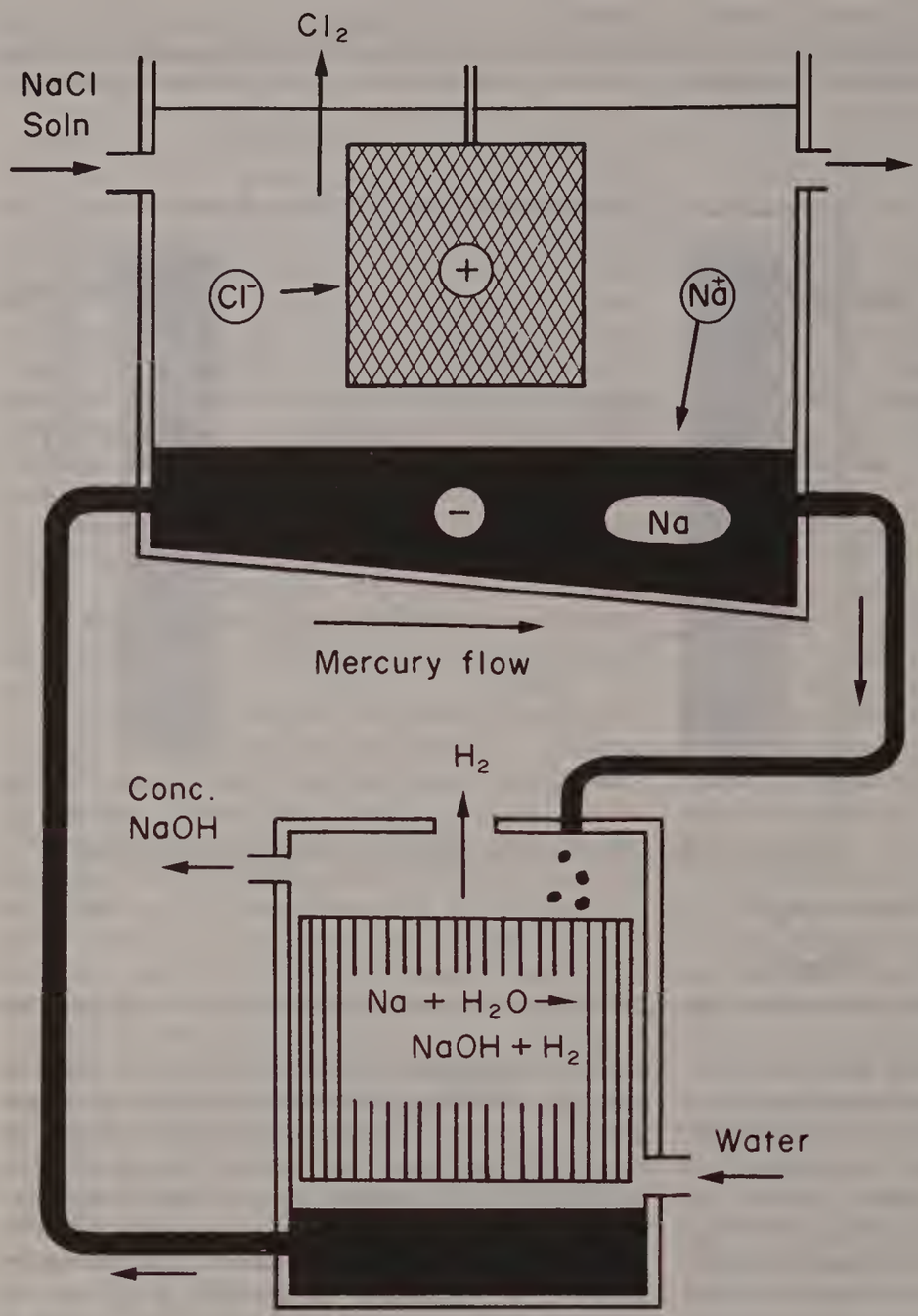
Like in a simple electrolysis cell, chlorine gas is produced at the anode of the mercury electrolysis cell (termed an 'electrolyzer'). Sodium hydroxide is generated only after the sodium amalgam flows from the electrolyzer into the decomposer unit—where the sodium reacts with water to form NaOH. The decomposer consists of a vertical steel column lined with graphite packing. Mercury amalgam is broken into droplets and, on its downward passage through the rising flow of de-ionized water, reacts with the water. The substantial energy liberated by this reaction (which is derived from the higher operating voltage for the mercury electrolysis cell) could theoretically be recovered and utilized, but this has never been economically feasible. After passage of the mercury through the decomposer, it is returned (now free of sodium) to the electrolyzer.

The energy required to electrolyze salt solution and evaporate NaOH product solution is a major component of the operating costs of a chloralkali cell. Mercury electrolysis cells require considerably more electrical energy than alternative mercury-free electrolysis cells, but this is offset by the smaller amount of heat required to evaporate the alkali product of mercury cells. Because sodium hydroxide is generated in a unit entirely separate from the electrolyzer, it can be produced at very high concentration (50 - 70% NaOH) and virtually free of NaCl impurity. Overall, about the same energy is required with the mercury cell process as is consumed in the alternative mercury-free diaphragm cell process.

Mercury is an expensive material. It comprises a significant portion (10 - 15%) of the total investment for mercury chloralkali cells. Despite the value of mercury, relatively little effort was expended until recent years in preventing mercury losses to the environment. The electrolyzer and decomposer of the mercury cell process operate at elevated temperatures, at which mercury has a substantial vapor pressure. Without emission control processes, mercury is lost in the gas streams, products and liquid waste streams of a mercury electrolysis plant. Prior to government regulation, mercury losses of 250 grams for each ton of chlorine produced were considered normal in both North America and Europe.

The decomposer of a mercury cell operates at 70 - 100°C, and the hydrogen gas stream leaves the decomposer saturated with mercury vapor. This alone represents a potential mercury escape of at least 180 grams per ton of chlorine produced. Most can be removed by compressing the gas stream to about 4 atmospheres pressure, indirect cooling with water to 30°C and chilling with Freon. Commercially available 'mist eliminators' can collect the fine liquid droplets of mercury which condense.

Although it is widely used for removing toxic compounds from waste streams, activated carbon—by itself—has not proved very useful as an adsorbent for



The 'arch villain' of mercury pollution has been the mercury chloralkali cell used for the industrial production of chlorine and sodium hydroxide. It employs a cathode of flowing mercury metal, upon which sodium metal is electrodeposited. By forming a liquid sodium amalgam (a mercury alloy), the sodium is kept from contact with the brine solution (with which it would immediately react). The electrolysis of sodium requires a substantially higher voltage than is needed to liberate hydrogen gas and hydroxide ions.

This extra electrical energy is liberated as heat in the decomposer unit (shown below), where the sodium-mercury amalgam is reacted with water, forming a highly concentrated and very pure solution of sodium hydroxide. Formation of NaOH in a separate unit from where chlorine is produced avoids the possibility of the two products coming into contact and reacting.

mercury. Other materials have been found to be more effective for removing mercury vapor: aluminium oxide or activated carbon impregnated with silver or iodine, thin films of noble metals on glass wool, or thin films of noble metals alone. Molecular sieves have also been developed specifically for mercury removal. Used in conjunction with chilling and demisting, molecular sieves are a practical method for reducing mercury levels in hydrogen to extremely low levels (corresponding to 2.5 milligrams loss/ton Cl_2 produced, or about *1/100,000* the loss without any emission control measures). Another very effective method is chemical scrubbing with an alkaline aqueous solution of sodium hypochlorite and sodium chloride. In all these methods, mercury can be recovered and recycled, but all entail additional capital and operating costs.

Mercury removal from waste brine streams requires a different approach, since nearly all mercury in spent electrolytic brine is present as the stable, soluble complex, $HgCl_4^-$. The first mercury control method to be widely adopted was precipitation of the complex as insoluble mercuric sulfide, and removal of the particles by settling or filtration. Care is required to ensure that the waste stream has first been completely freed of chlorine and that the sulfide precipitating agent is not added in large excess. Another procedure utilizes starch xanthate as a precipitating agent, with a synthetic polymeric flocculating agent. It produces a mercury-containing precipitate that settles readily and can be easily filtered.

Another approach uses alloys of reactive metals to chemically reduce the mercuric complex in solution to insoluble metallic mercury, which can then be recovered. For example, passage of the waste brine stream through a bed of granulated zinc rapidly and efficiently removes mercury. In reducing the $HgCl_4^-$ ion, the zinc is oxidized to soluble Zn^{+2} ions. The reaction thus exchanges zinc, which is also toxic—but to a lesser degree, for mercury. Less toxic replacement can be carried out with silicon-iron alloys. An even less harmful reductant is sodium borohydride, although it is expensive in the amounts needed to remove mercury (0.5 gram $NaBH_4$ for each gram of mercury removed). Formaldehyde and other organic reagents can rapidly reduce mercuric ion to metallic mercury, contributing only biodegradable com-

pounds to the wastestream. This reaction (which is the basis of the simple 'silver mirror' test for aldehydes) is an economical and environmentally favourable alternative to the use of metallic reductants.

Application of these and other methods have allowed emissions by mercury cell electrolysis plants to be significantly reduced, but not nearly as much as is desirable or possible. For example, treatment of hydrogen and vent gases in Canadian mercury electrolysis plants have cut mercury losses to the atmosphere to about 6 gram/ton chlorine. Nonetheless, these discharges still cause a detectable elevation of mercury concentrations in the air and snowfall in the vicinity of mercury cell plants. Probably of greater significance is the sharp reduction of mercury discharges in liquid effluents, which in the majority of Canadian plants is now about one gram per ton of chlorine produced.

Mercury recovery and recycling has had a very significant effect on overall mercury combustion by the chloralkali industry—which in 1976 consumed one-fourth as much mercury as was needed prior to 1970. Average mercury losses by Canadian chloralkali plants (in air, liquid effluents, brine sludges, solid wastes and unaccounted losses) have been reduced to an estimated 13.1 gram/ton Cl_2 product. Even so, when *total mercury consumption* of the chemical industry is compared with *total chlorine production* by mercury cells, mercury losses are still twelve times the level allowed by regulatory agencies of the Canadian government (2.5 gram/ton Cl_2 for atmospheric losses, and 5.3 grams/ton Cl_2 for losses in liquid effluents). It is difficult to estimate how much of the mercury loss by the chemical industry is deposited in properly-constructed landfill sites, and how much reaches the 'biosphere' in which we live.

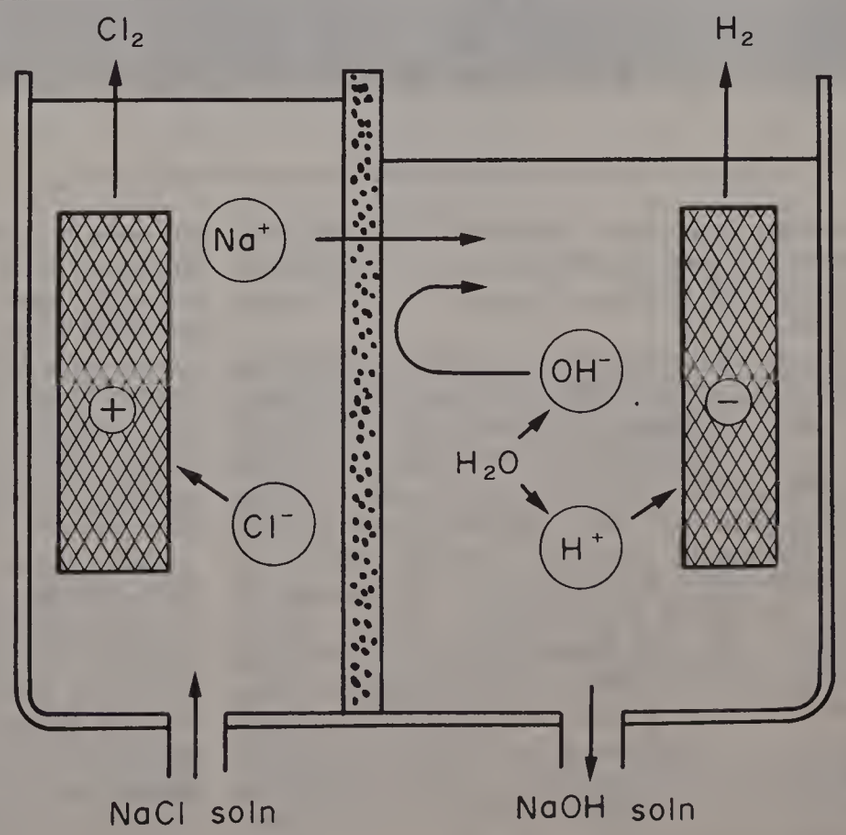
Mercury emissions in Canada have been reduced to a greater extent than in most other countries (outstanding progress has also been made in Sweden and Japan). The escape of mercury directly into Canadian waterways is now less than 1% the 1970 loss rate. However, mercury cell facilities vary greatly in the degree of mercury control that they are able to achieve. For one thing, mercury recovery can generally be carried out more effectively with chloralkali cells of recent design than is possible with add-on treatment units applied to older chloralkali cells.

Reduction of mercury discharges to 1% of former levels has been accomplished without placing an excessive economic burden on the chloralkali industry. Further reductions would entail rapidly increasing costs. The logical pathway to reduce mercury emissions even further is not by the application of more efficient (and more expensive) mercury recovery equipment, but by abandoning the mercury cell process.

This has been the approach of the Japanese, who are working to eliminate the type of industrial water pollution that had caused widespread illness ('Minamata disease', later identified as chronic mercury poisoning) and more than 50 deaths among people eating contaminated fish from Minamata and Niigata Bay. The Japanese government decided in 1974 to initiate a programme to convert all chloralkali plants to non-mercury processes. Prior to this, about 99% of chlorine and sodium hydroxide produced in Japan was made in mercury cells.

The transition to a mercury-free chloralkali industry was to be undertaken in two steps. Eventually, all plants are to be converted to the membrane cell, but this technology had not yet been proven at the time the Japanese government launched their programme. The first step of the conversion was to adopt the diaphragm cell process. Most chloralkali plants in Japan now use the diaphragm cell process.

Also in North America, where the chloralkali industry is based on natural brines, a significant proportion of chloralkali plants has converted to



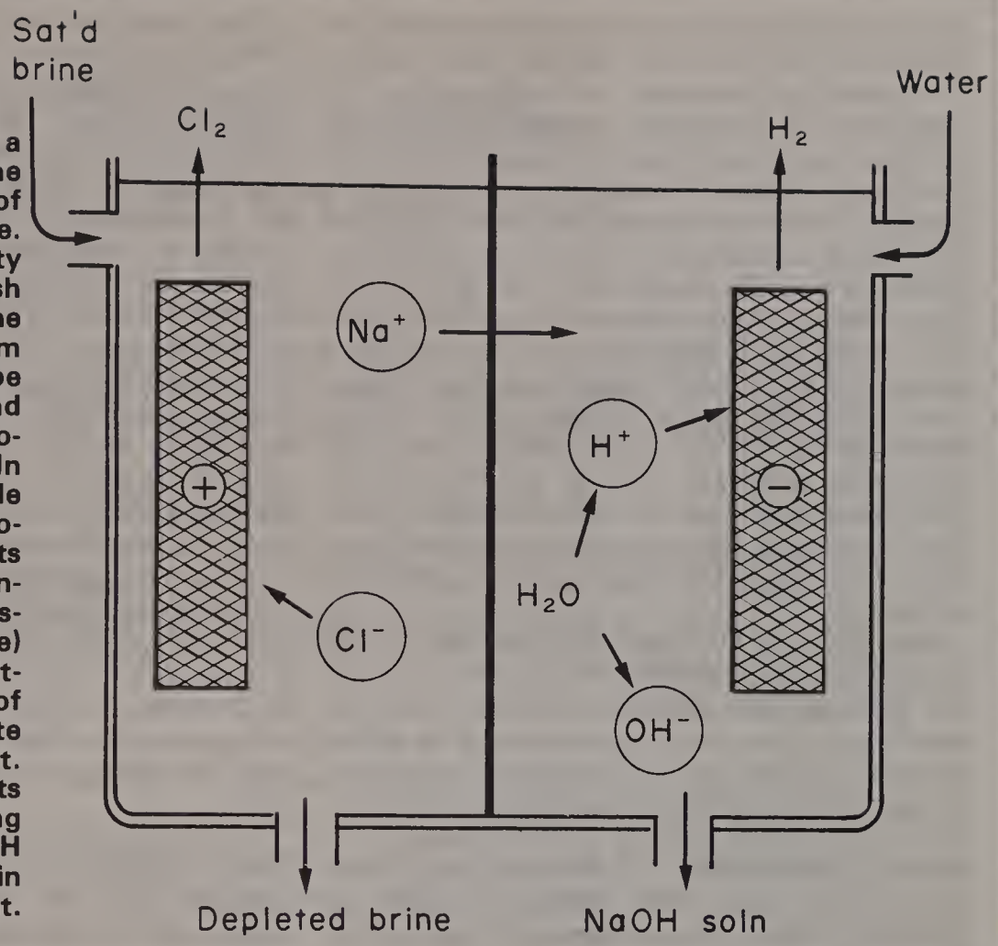
The diaphragm electrolysis cell produces hydrogen directly at the cell cathode, and thus, does not need or use mercury. Hydroxide ions, which are produced near the cathode, migrate through the electrolyte solution and are attracted towards the anode, but are prevented from crossing the porous diaphragm by the flow of electrolyte in the reverse direction. Instead, sodium ions flow from the anode to cathode compartments, carrying an ion current that balances the electron current into the cathode electrode and out from the anode.

Chlorine and NaOH are made in banks of electrolyzer cells, such as the diaphragm cells shown above. Each cell is capable of producing about one ton of chlorine and 1.1 tons caustic per day. Chlorine is collected from the top of each cell, and then cooled, dried and liquefied in towers such as the ones seen below. To avoid the possibility of leakage to the atmosphere, the entire chlorine collection system is maintained slightly below atmospheric pressure by oil-free vacuum pumps (*photographs by Prof. Hocking*).

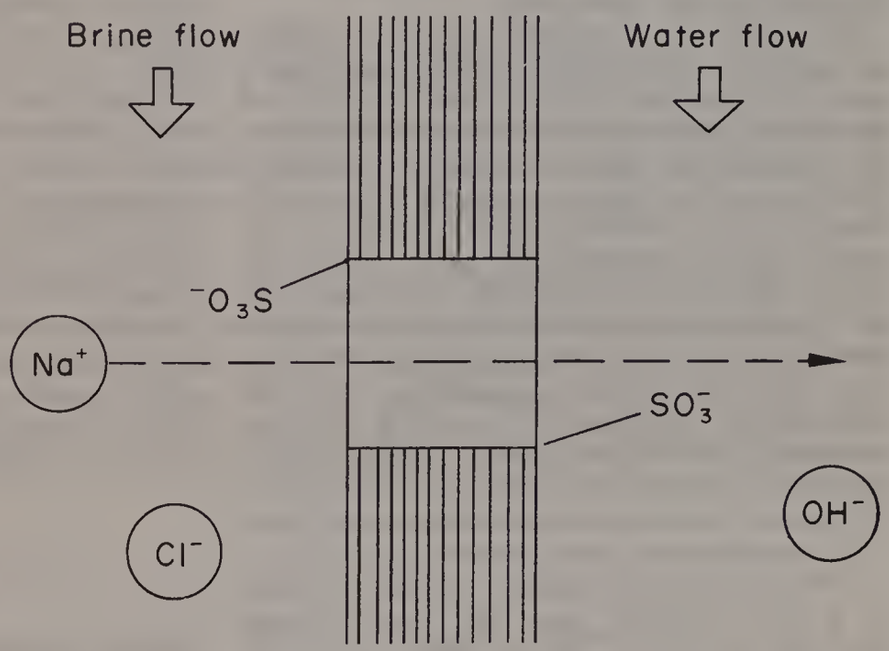
diaphragm technology. About 68% of Canadian chlorine and sodium hydroxide is now made by the diaphragm cell process, and about 79% of US production.

In most other countries, the predominant share of chlorine and caustic is still produced by the mercury cell process. European producers have been reluctant to adopt diaphragm cell technology for several reasons. Firstly, salt used as feed for the European chloralkali industry has traditionally been supplied and transported in solid, crystalline form. The crystalline salt is a purer source of sodium chloride than the natural brine solutions used by North American chloralkali plants, and is ideally suited for mercury cells. Secondly, Europe has indigenous supplies of mercury in Spain and Italy, while asbestos (needed for diaphragm cells) is native to Canada and the United States. Other porous materials have been examined as potential substitutes for asbestos, but none has tolerated the extremely corrosive environment in a chloralkali cell. Finally, sodium hydroxide made by diaphragm cells is not as pure as that made by the mercury cell process (typically containing about 1% NaCl and 0.1% $NaClO_3$). Because European chemical industries have traditionally relied on sodium hydroxide made by the mercury cell process, they may be more hesitant to adopt their secondary processes to the lower-purity sodium hydroxide made by the diaphragm process.

Unlike the mercury cell, the diaphragm cell produces hydrogen and generates hydroxide ions directly at the cathode. Sodium hydroxide produced at the cathode is separated from chlorine liberated at the anode by a porous asbestos diaphragm (an asbestos fibre mat supported on an iron grid). Fresh brine is continuously added to the anode compartment, maintaining its liquid level higher than in the cathode compartment. Electrolyte seeps through the dia-



Membrane cells utilize a cation-exchange membrane to prevent passage of hydroxide ions to the anode. The membrane selectivity blocks negative ions. Fresh brine is supplied to the anode compartment, from which sodium ions escape through the membrane and chloride ions are electrolyzed to chlorine gas. In passing through the anode compartment, the electrolyte becomes depleted of its initial NaCl content. Meanwhile, sodium ions (diffusing through the membrane) and hydroxide ions (resulting from electrolysis of hydrogen ions) accumulate in the cathode department. The membrane prevents chloride ions from entering the concentrated NaOH product that is formed in the cathode compartment.



The pores of the membrane are guarded by negatively-charged sulfonic or carboxylic groups, as shown in this idealized schematic diagram. Sodium and hydrogen ions can migrate through the membrane pores—as indeed they must for the cell to operate, but hydroxide and chloride ions are prevented from passing by their large size and positive charge. Stringent requirements are placed on the purity of brine used in membrane cells, since divalent calcium, magnesium and ferrous ions bind to the membrane and reduce its permeability.

phragm at a carefully-controlled rate towards the cathode. The one-way flow of electrolyte prevents hydroxide ions from migrating upstream to the anode compartment. A flow of sodium ions through the diaphragm balances the electrical current to the electrodes.

The formation of sodium hydroxide in the cathode electrolyte solution imposes limitations on the purity and concentration of caustic that can be produced. Fresh brine must be continuously added to the anode compartment and sodium hydroxide product solution continuously withdrawn from the cathode compartment to maintain a constant anode-to-cathode flow of electrolyte solution. This prevents sodium hydroxide concentrations from reaching the high level possible in a mercury cell decomposer. Generally, sodium hydroxide made by the diaphragm cell emerges from the cell containing about 12% NaOH and 14 - 15% NaCl. After evaporation of excess water and crystallization of the salt, the filtrate contains 50% NaOH (compared to 50 - 70% NaOH made directly by the mercury cell process). The process thus requires more steam to evaporate the NaOH solution to a dry product, but needs less electrical energy. The availability of low-grade steam is therefore an important economic factor favouring the diaphragm cell process.

Even with respect to environmental pollution, diaphragm cells are not completely free of potential problems. Use of asbestos in the cell separator opens

up the possibility that asbestos fibres could enter the product streams and be carried into plant effluents.

In order to overcome the limitations of the diaphragm cell and produce sodium hydroxide with the same high purity (typically, containing 0.005% NaCl) as the product of mercury electrolysis cells, the membrane cell was developed. It utilizes a synthetic fluorinated polymeric cation exchange membrane, instead of a porous diaphragm. Although the membrane serves a similar function in separating solutions in the anode and cathode compartments, it operates by an entirely different mechanism. Migration of hydroxide ions is blocked, not by a flow of electrolyte, but by the selective action of the membrane. The membrane pores are guarded by negatively-charged sulfonic or carboxylic acid groups. Only the small positively-charged ions of sodium or hydrogen are allowed to pass through the microporous membrane.

In a membrane chloralkali cell, fresh salt solution enters the anode compartment—as in the diaphragm cell. However, the solution leaves the same compartment when it has been largely depleted of sodium chloride. Chloride ions are removed by electrolysis, and sodium ions diffuse through the membrane.

On the opposite side of the membrane is the cathode compartment, supplied with pure water. Sodium ions enter this solution through the membrane, and hydroxide ions are generated as hydrogen ions are electrolyzed.

To resist the extremely corrosive alkaline environment in a chloralkali cell, the membrane is made of a perfluoro polymer. Fluorosulfonic acid terminating groups were found to bestow the desired ion selectivity, and are used in 'Nafion' membranes made by the US chemical company, E. I. DuPont de Nemoirs. These membranes have operated successfully for periods exceeding two years, without any sign of chemical deterioration. However, because of the hydrophilic nature of the sulfonic acid group, some hydroxide ions escape through the membrane pores into the anode compartment. The lost hydroxide can be replaced, but only with additional consumption of electrical energy. Higher electrical efficiency is attained with perfluoro membranes with sulfonamide guarding groups, but these are more prone to deterioration in the corrosive environment.

These shortcomings appear to be largely overcome in a new membrane made by Asahi Chemical Company in Japan. It has carboxylic acid groups guarding the pores of the thin fluorocarbon sheet. Carboxylic groups, it is claimed, are better able to block migration of hydoxide ions and resist corrosive attack. As a result, production of chlorine and alkali per unit of electrical power is only very slightly less in the Asahi membrane process than is attained by modern diaphragm electrolysis cells.

The Asahi membrane process was introduced in 1975, and now accounts for 160,000 tons of chlorine production in Japan and Canada. Plants presently under construction will add an additional 300,000 tons capacity in the Netherlands, Japan and New Zealand by 1982. By the end of 1984, the membrane cell process could account for 1.5 million tons capacity in Japan alone. This country, and others that become committed to the membrane process, will then be well on the way to an economically—competitive mercury-free chemical industry.

Another promising—although still experimental—development is a new type of chloralkali cell which electrolyzes *molten* sodium chloride. The cell is similar in concept to the conventional Down's cell for the manufacture of chlorine and liquid sodium metal. It differs, however, in that it uses a ß-alumina diaphragm to separate the molten sodium hydroxide product (containing a small amount of water) from a $NaCl\text{-}ZnCl_2$ electrolyte. This is believed to be the first application of ß-alumina, a solid ceramic material which conducts sodium ions, in a device for the electrolysis of molten salts (ß-alumina is also employed in experimental high-temperature sodium - sulfur batteries).

The molten-salt chloralkali cell operates at about 330°C, slightly above the melting point of pure sodium hydroxide. Preliminary laboratory-scale experiments have demonstrated the extremely high electrical efficiency of the cell, and the good resistance of the ß-alumina diaphragm to hot alkaline salts.

These results have encouraged researchers at Kyoto University in Japan to scale-up their experiments. Recent experiments, reported Dr. Shiro Yoshizawa to the 1979 meeting of the International Society of Electrochemistry, have utilized electrolysis cells with 0.5 metre-long ß-alumina tubes and electrical currents of 100 Amperes (corresponding to a chlorine production of 3 kg/day). If the molten-salt chloralkali cell proves viable on a commercial scale, it could provide yet another alternative for the chemical industry to be freed of its reliance on mercury and the hazards of mercury pollution.

Additional information:
Those desiring additional information are referred to the 279 page report "Effects of Mercury in the Canadian Environment" published by the National Research Council of Canada (Report No. 16739). The report was prepared by a nine-member panel, including Prof. Hocking (serving as associate editor), and is available for C$3.00 from: Publications, NRCC/CNRC, Ottawa, Ontario K1A 0R6, Canada.

Writing technical articles to be read and understood

Technical articles are written to convey information. In this respect, they are different from best-selling novels or articles read for entertainment in popular magazines. But this is where the difference ends. It is not essential that technical articles be difficult to read, boring or tedious; however they usually are.

Why are so many chemistry articles so difficult to read and understand? Is it because many chemists attach little importance to good writing, or because they must conform to a bland style that has become universally accepted? Are researchers afraid that clear, straightforward presentation of their results will expose them to criticism? Or, do chemists become so involved with their research projects for so long that they assume the basic background information is known to everyone?

This article does not answer these questions. Rather, it is intended to provide helpful hints for chemists to improve their writing. These suggestions are the distillate of the Editor's experiences during many frustrating hours spent in the library as a student and chemical researcher, and during four years work as a professional writer/editor of chemistry and chemical engineering articles.

The suggestions presented here are simply . . . well, suggestions. They are not formal IUPAC recommendations. There is no single best way to write an article, but a few general techniques are nearly always used by experienced technical writers. These are very simple, perhaps obvious, yet they are commonly ignored by the scientific community. In this article, we examine these techniques.

The guidelines presented here apply to writing any kind of technical article, but additional factors must be considered when preparing articles for publication in primary research journals. For these, it is necessary to completely describe experimental details, refer to other research papers, use computer retrievable words in the title, and adhere to specific requirements of journal editors.

Writing an article is very much like doing research. At the outset, everything is done meticulously, and nothing works. As time goes on, more and more shortcuts are taken, and the results get better and better. This apparent inconsistency can be explained very simply. Most experimental procedures are effective, no matter how casually they are done. Others are critical: a slight change in temperature, an impurity in one reagent, or a different stirring speed will alter the outcome of an experiment. With experience or guidance, one learns *which* aspects can be approached casually, and *which* require careful attention. The same is true of writing technical articles. On the following pages we'll explore those features that are most important for an article to be readable, understandable and . . . even interesting.

REPRINT ORDERS

A limited number of reprints of this report are available for purchase. They may be ordered in lots of 25 at a cost of £5 (or US$12)/25 copies, including surface mail postage. Orders should be accompanied by a cheque payable to IUPAC, and sent to *Chemistry International,* IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.

I. Giving the reader what he needs

A technical article represents the climax of a research project or study. Publication of articles is therefore often used to gauge the progress or productivity of a chemist or his research project. The strong emphasis that has been placed on publishing papers has obscured a critically important point: papers are published for the benefit of the readers. Consequently, the first thing that a prospective author should consider is *who* will be reading his article, and *what* such readers would most want or need to know about the project.

Obviously, an article written for a highly specialized research journal should be written in a very different way than an article written for say, *Nature, Scientific American* or *Chemistry International.* For example, a new technique for chromatographic separation of enzymes should be described very differently in an article published in a chromatography journal, and an article appearing in a biochemistry journal. Those reading a chromatography journal would likely want to read about the technique, but should not be expected to have any knowledge of enzymes. A reader of a biochemistry journal would likely know a lot about enzymes and be very interested in how they may be separated, but would only be interested in the chromatographic technique as an experimental tool.

The separation of chemical knowledge into distinct areas of specialization, each covered by a few journals, might well be eroded by the increasing use of computers to search out and retrieve articles from the entire chemical literature. This technology allows a researcher to scan thousands, or possibly millions, of articles, and locate those having selected key words in the title, a specified author, or date of publication. No doubt, it will eliminate hours now spent trying to locate very specific information, and will likely guide chemists to journals that they otherwise would not read. Nonetheless, at the output end of this revolutionary microelectronic technology must be someone who can read and understand the articles, who can assimilate the information, and use it.

Even more than in the past, *reading* will be the rate-determining step in the transmission of information. While the enormous capacity of the human mind to store and digest information has frequently been cited, most people grossly overestimate the rate at which *new* information can be assimilated. It is the main limitation of transmitting information from one human being to another. Authors should always bear this in mind, and not compress too much information into the space allotted for an article.

The presentation of too much information is compounded by a lack of background information necessary to understand the subject and its discussion. By the time a chemist is preparing an article, he has likely spent a very long time studying, working and thinking about his project. His intimate knowledge of the subject will have been developed over a period of years. He cannot expect to explain all its aspects in one article, nor is it reasonable to assume that familiar concepts are self-evident to others. Too often, it is assumed that readers share the basic background knowledge and terminology needed to understand the author's project.

The best way to ensure that an article does not present too much information, and contains all the background information it should, is to have the article critically appraised by someone who is not involved in the project and with sufficient professional standing to admit that he doesn't understand the article. Journal referees are ideally placed to suggest improvements for the readability of submitted articles, rather than interpreting their role solely as a judge of research quality.

II. Select core ideas for the first draft

The first step in preparing an article is to think about what it should say. You might briefly review the material available, and then select *a few main points* on which the article will focus. These concepts or conclusions will form the core of the article, and all material in the article should be directed at supporting these few ideas, or presenting background material so that they can be understood. Anyone reading the article, even if he/she is a specialist in an entirely different area of chemistry should be able to understand these main points. If the article is short, it should be built around *one* main point.

Unless you intend to write a review article (surveying progress in a selected area of chemistry), you should not attempt to make your article comprehensive. On the contrary, you should be very *selective* in discussing only that material which supports the main conclusions or arguments that you are trying to bring to the attention of readers. Additional material will simply diffuse the attention of readers with material of less significance.

The same selectivity should be exercised when a title is written. Bear in mind that the article is not discussing *a subject*; it is discussing your *main conclusions.* Consequently the title should not simply define the subject area to be covered by the article, but should relate to the main points on which the article is focussed. The title should be as brief as possible. Complex terminology should not be used if common words can serve the same function. A good title describes uniquely the content of the article. It is often helpful to prepare a tentative title before starting to write a manuscript, as this may help delineate those aspects which should, and should not, be discussed. After the article is written, you should reconsider your tentative title, and revise it if it can be improved.

As well as composing a preliminary title, some authors prepare an outline before beginning to write an article. An outline lists the main subjects to be covered in the article, in the order in which they are to be discussed. An outline is often useful, but it is not necessary that the main subjects or their sequence be rigidly decided beforehand. Even if you write the article following an outline, your discussion may drift

into other subject areas, and these sections should later be shifted to suitable parts of the manuscript. After the first draft is prepared, you may wish to include additional material, delete other material, or transpose the sequence in which the various subjects are discussed.

Many potential authors allow themselves to be antagonized by the opening sentence. They roll a fresh sheet of paper into their typewriter, and stare at it, pondering the perfect beginning. The inspirational sentence may not come for hours, and an author will usually give up and abandon the typewriter before one emerges. Creative writing is something that happens spontaneously when you are in the mood, and is virtually impossible to do at other times. So when you feel like writing, you should make the best use of this precious time. Don't waste time pondering the opening sentence; you'll probably want to re-write it later anyway. Don't dissipate your attention by checking word spellings, or counting graph points: keep writing, and circle in pencil any words or numbers that you wish to check later.

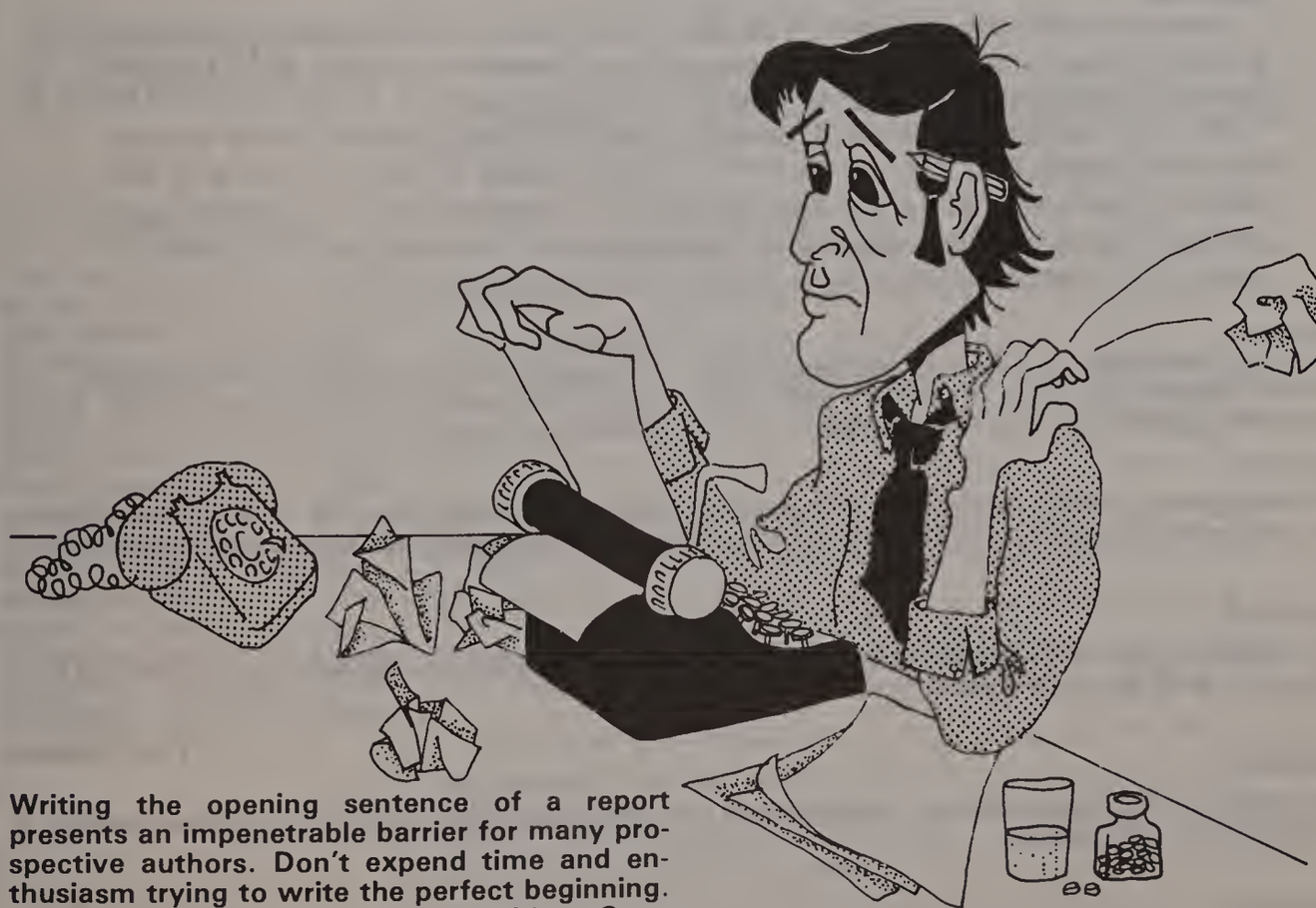
The best way to get in the mood for writing is to *start writing.* You need not start writing at the beginning of the article. There are no laws about which sections must be written first. Why not start with one aspect that seems particularly interesting at the moment? Ultimately, the various sections will fall into a logical sequence, and follow smoothly one after another.

Many authors have the pre-conceived notion that technical articles should be written like epic tales, building up to the most interesting and dramatic conclusions at the end. This forces the reader to scan the entire article before he knows if it contains useful information. Far more likely, he will stop reading before he had learned anything. Sometimes, it *is* necessary to present background information first so that main conclusions can be understood. However, unless there is reason to do otherwise, present the most interesting and important material near the beginning. Once the article has aroused the attention of the reader, it can discuss underlying reasons, consequences and subtle implications. When all pertinent material has been presented in support of your main arguments, *stop.* That is the end of the article.

Once you have completed a first draft, it should be typed double-spaced on white paper. When you later read it, it may seem that the material could be presented more logically in a different sequence. You might also find that some paragraphs have digressed into peripheral discussion, and should be deleted. Elsewhere, you will find gaps where additional paragraphs are needed to fill in information you have forgotten to include.

III. Metamorphosis of a manuscript

The first draft of the article is an important stepping stone, but will likely have little resemblance to the final manuscript. The more you refine the first draft—by elaborating on those points you initially covered too superficially, cutting out paragraphs that don't lead anywhere, and rewriting sentences or para-



Writing the opening sentence of a report presents an impenetrable barrier for many prospective authors. Don't expend time and enthusiasm trying to write the perfect beginning. The important thing is to start writing. Once you have 'broken the ice' and plunged into the subject matter, the words will flow onto the page *(cartoon for Chemistry International by Maryse Worrallo).*

graphs that are not completely clear—the better it will become. You may find that major changes are necessary at first. Where paragraphs or larger sections have been shifted to a new place in the manuscript, you may need to modify the opening sentence of the new section, alter the closing section of the preceding section, or write a new 'bridging sentence' to carry the discussion smoothly from one subject to the next. Later, minor refinements of wording and phrasing will be needed. When you have finished, your 'polished' manuscript should read smoothly, with the discussion flowing naturally from one part to the next.

Don't be overly concerned with neatness until you are completely satisfied that the manuscript is ready for its final typing. During your editing and rewriting of the first draft, a few pages may need major changes, and these pages should be retyped. Usually, this will not be necessary. Minor corrections can be made by placing white correcting tape over the original line, and typing over it. When paragraphs need to be rewritten, they should be typed on a separate sheet of paper. Cut out the new paragraph with scissors, place over the original, and hold in place with transparent tape (the best type to use is "invisible" tape, about 12 mm wide, made by 3M or Sellotape). If a new paragraph is longer than the original one, it may be typed single-spaced to fit over the same area.

Using scissors and transparent tape, entire sections can be cut out and shifted to new positions in the manuscript. Sections to be deleted can be covered with a blank piece of paper. Additional paragraphs can be typed on a new sheet of paper, with other paragraphs cut out and taped into their proper sequence.

You will likely find yourself rewriting sentences and paragraphs that have already been rewritten once or twice. This is to be expected, as rewriting a paragraph will affect the content and outlook that should be presented in the preceding and following sections. By changing the manuscript, part by part, it converges into a logical, self-consistent presentation of the subject matter.

By the time you have finished editing and rewriting, each sheet of the manuscript might have layers of

A technical writing test

After reading the suggestions presented in this article for writing and editing technical articles, you may wish to evaluate your skill. Here, we present a few sentences that are clumsily worded and unnecessarily complicated—very similar to those you may encounter in your own first draft, or published in the chemical literature. Using the principles discussed in this article, see if you can rewrite each sentence to be simpler, clearer and easier to understand—yet have virtually the same meaning.

There is no one correct answer. You may, however, rate your sentence by giving it 5 points for each word by which the sentence length has been reduced, and 25 points for each complicated term that is replaced by simple words.

The first sentence is presented as an example, with one possible correct answer shown alongside. A score, the number of points gained by this rephrasing of the sentence, is also shown. For the other sentences, 'correct answers' are provided near the end of the article. Beneath each of the sentences is 'par value' for the number of points you might expect to achieve by rewriting the sentence.

Sentence 1

A vigorous ebullition in the solution was clearly seen to occur when the line from the vacuum pump was connected, tightened and the valve opened.

Possible answer:
The solution boiled when vacuum was applied.
Score: 100 points (length reduced by 15 words, "ebullition" replaced)

Sentence 2

To obtain greater yields of condensable hydrocarbon fractions with boiling points of not less than 40°C than one could otherwise expect to achieve on a routine basis, a fluidized-bed cracking process was developed.

Par: 95 points

Sentence 3

The etiological agent of the disease was found to be associated with the consumption of grain that had been left on the fields during war years.

Par: 75 points

Sentence 4

This inability to distinguish between exogenous and endogenous trace elements presents a serious problem in the analysis of hair samples.

Par: 55 points

Sentence 5

Striking similarities were observed in the pathology of the Balkan syndrome and ochratoxin-induced porcine nephropathy in terms of renal structure and function.

Par: 105 points

rewritten sentences and paragraphs taped one over another. The manuscript might appear outlandishly sloppy at this point, but will provide surprisingly neat photocopies (since photocopiers cannot distinguish the different shades of white of the original manuscript, correcting tape, and taped-on alterations). These photocopies can be given to colleagues for their appraisal. To receive objective comments, you should not ask someone who is well acquainted with your work, or a subordinate who might be reluctant to criticize the manuscript. After comments and suggestions are incorporated, the manuscript is ready to be retyped and submitted to the appropriate journal (if it is a report to be printed, a photocopy of the manuscript can be submitted directly to the typesetter).

During the final 'polishing' of the article, you should be concerned primarily with altering those sentences that are not absolutely clear. You need not have intimate knowledge of English grammer to ensure that your sentences are lucid and readable. In fact, it is most essential that you *keep your sentences as simple as possible.* A few simple guidelines may help you.

Firstly, keep your sentences short. This doesn't mean that *all* sentences should be short interjections. Variety is the 'spice of life' and this is true of the variation in sentence length which marks good writing. A good rule-of-thumb is not to jam too much information into one sentence. Use short sentences when explaining complicated ideas. Longer sentences are well suited for explaining relatively simple or straightforward ideas. But regardless of how complex or simple the subject under consideration, excessively long sentences should be avoided.

Secondly, cut out words or phrases that add nothing to the meaning of a sentence, but clutter it with additional words. Phrases like 'This seems to indicate that . . .' can be condensed to 'This indicates that . . .' without any loss of content.

Thirdly, do not use complicated or vague terminology when the same information can be conveyed with simple words. Some authors refer to the 'etiology of disease' when they could write the 'cause of disease'. 'Methodology' conveys no more information than the word 'methods', but its meaning is less specific. An enormous number of common examples may be found in the chemical literature where complicated terms can be replaced by simple words.

Finally, give your sentences life by using verbs. Verbs are words of action and movement. Use verbs whenever you wish to describe something happening, moving, or doing something. Consider, for example,

EVOLUTION OF A MANUSCRIPT

(1) THE FIRST DRAFT

The first draft of a manuscript, like the one shown here, should be proof-read carefully and critically. Diagrams on the following pages show how this manuscript might be altered, step-by-step, into a clear readable article. During this evolutionary process, some sections will be rewritten, some shifted to new positions in the manuscript, others will be deleted and additional background information inserted where necessary.

COLLABORATIVE ANALYTICAL STUDIES

The International Symposium on Harmonization of Collaborative Studies, to be held in Helsinki, Finland on 20-21 August, has been organized in recognition of the importance of such studies in many areas of everyday life ranging from health and environmental standards and control to all aspects of industry and commerce. Interest is both national and international. The symposium will be of direct interest to organizations which sponsor collaborative analytical studies and those who participate in such. There is now considerable interest in avoiding duplication and recognizing a sound basis for the comparison of two or more methods each of which has been validated by collaborative study.

The symposium will consider the role and design of collaborative studies, with special reference to analytical parameters which are important in the validation and intercomparison of methods (eg accuracy, precision, reproducibility) and the definition and practical interpretation of such parameters.

the sentence, 'A foaming effect was clearly visible in the solution at the bottom of the flask.' It is simple, short, and contains no complicated terminology. Yet, it is lifeless and limp. Why not write, 'The solution *foamed* at the bottom of the flask.'

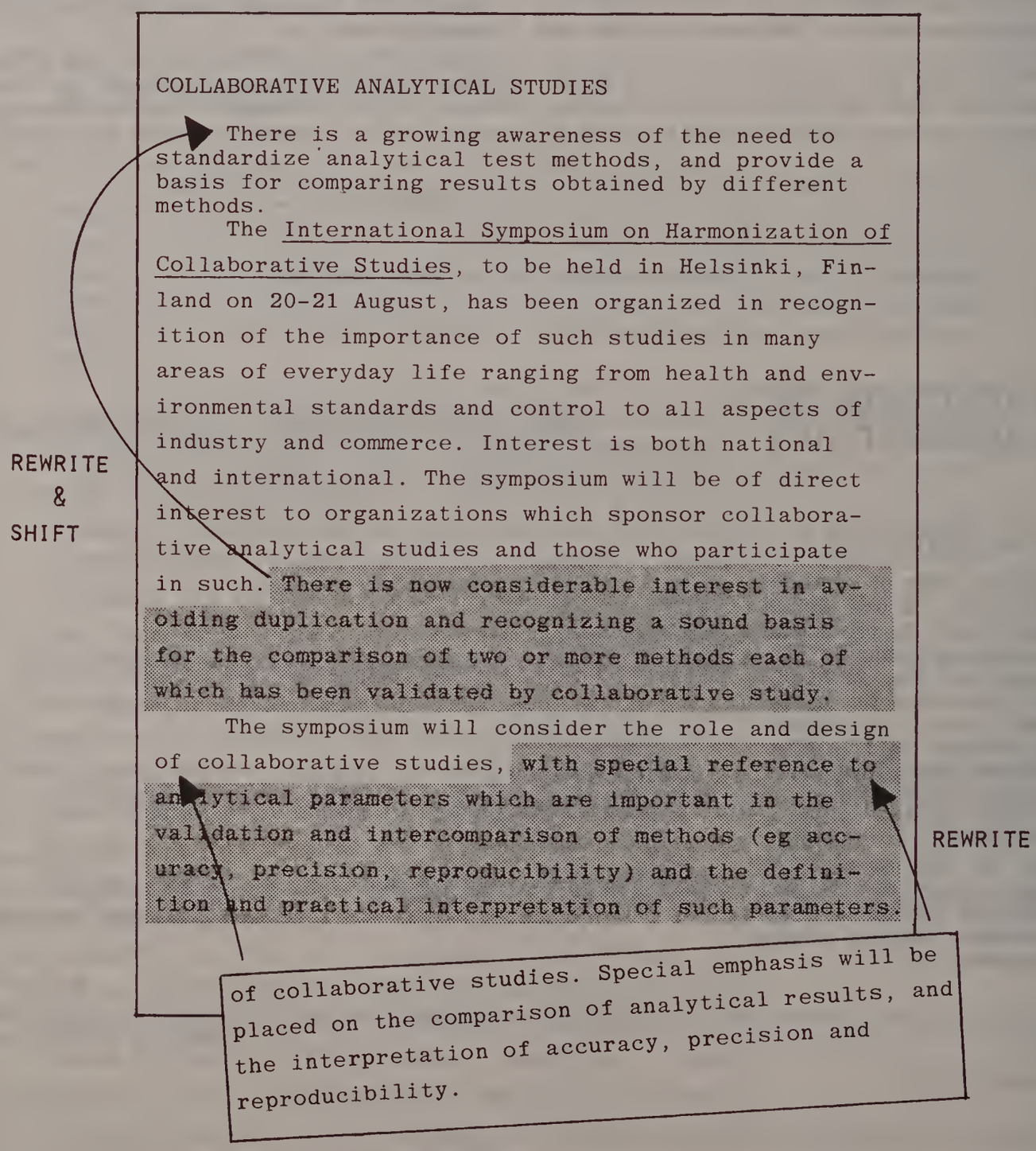
The information content of an article need not be conveyed entirely by written text. Diagrams or photographs can augment a written explanation, and help present concepts that are difficult to describe in words. Photographs or well-planned diagrams instantly disclose the content of the article, while the significance of printed text can easily elude a tired or hurried reader. At the very minimum, photographs and diagrams relieve the monotonous appearance of numerous pages of printed text.

Many authors include a photograph or diagram in their article only when it is blatantly obvious that one is needed, or if one has already been obtained with

(2) CUTTING OUT & CUTTING IN

The main concept of the first draft is contained in the sentence, "There is . . . study." (shown in gray). This is a logical statement to begin the article, although its awkward wording needs to be simplified. The sentence can be rewritten, typed on a separate sheet of paper, cut out, and taped into position at the beginning of the article.

The second theme of the article is contained in the final paragraph, which consists of one excessively long and unwieldy sentence. It should be divided into two sentences, and the latter part (shown in gray) rewritten, and inserted into place.


COLLABORATIVE ANALYTICAL STUDIES
There is a growing awareness of the need to standardize analytical test methods, and provide a basis for comparing results obtained by different methods.
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The symposium will consider the role and design of collaborative studies, with special reference to analytical parameters which are important in the validation and intercomparison of methods (eg accuracy, precision, reproducibility) and the definition and practical interpretation of such parameters.
REWRITE & SHIFT
REWRITE
of collaborative studies. Special emphasis will be placed on the comparison of analytical results, and the interpretation of accuracy, precision and reproducibility.

great expenditure of effort. Far greater emphasis could be placed on the inclusion of illustrations in the technical literature. However, illustrations should be used only if they relate directly to the discussion in the article. Their function is to reinforce the comprehension and interest of the reader; not to reduce the work of the writer. Indeed, the amount of effort required to compose a diagram or obtain a photograph is often considerably more than the effort needed to write the same area of text.

When preparing an article, your ideas should be clear in your mind—at least by the time the article is complete, if not before. Preparing an article can be an important component of *doing* research, as well as *reporting* your results. It exposes gaps where further research is needed, encourages rethinking of conclusions, indicates those aspects that are most significant, and points the way for new projects.

(3) MORE CHANGES

The new opening sentence clearly states the reason for holding a symposium about collaborative analytical studies, but the article might state *why* it is important for analytical chemists to avoid duplication of test methods. This additional discussion, typed single-spaced to fit within the available area, is inserted over an original section to be deleted (in gray).

The following sentence, "The symposium . . . such" (also in gray), relates closely to the discussion in the second paragraph and should be shifted there.

ADD BACKGROUND INFORMATION

methods. Tests performed by various laboratories, each using their own test procedures, may provide widely different results for identical samples. Before a single test method can be recommended for universal use, collaborative studies must establish that accurate and reliable results can be obtained by participating laboratories in several countries. In recognition of the importance of such studies, an International Symposium on Harmonization of Collaborative Analytical Studies is to be held in Helsinki, Finland on 20-21 August.

COLLABORATIVE ANALYTICAL STUDIES

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SHIFT

The symposium will consider the role and design of collaborative studies. Special emphasis will be placed on the comparison of analytical results, and the interpretation of accuracy, precision and reproducibility. The symposium will be of direct interest to organizations which sponsor collaborative analytical studies and those who participate in such studies.

(4) POLISHING THE FINAL MANUSCRIPT

At this point, the manuscript might hardly resemble the first draft. Additional background information has been added; peripheral discussion has been deleted; the order in which the material is presented has been altered; and sentences have been reworded to convey their meaning in the simplest possible way.

Now, the suitability of the initial title might be reconsidered. The title should—if possible—state the main idea presented by the article, and not simply identify the subject.

NEW TITLE

ADOPTION OF STANDARD CHEMICAL TESTS WILL BE FOCUS OF INTERNATIONAL MEETING

~~COLLABORATIVE ANALYTICAL STUDIES~~

There is a growing awareness of the need to standardize analytical test methods, and provide a basis for comparing results obtained by different methods. Tests performed by various laboratories, each using their own test procedures, may provide widely different results for identical samples. Before a single test method can be recommended for universal use, collaborative studies must establish that accurate and reliable results can be obtained by participating laboratories in several countries. In recognition of the importance of such studies, an International Symposium on Harmonization of Collaborative Analytical Studies is to be held in Helsinki, Finland on 20-21 August.

~~and international. The symposium will be of direct interest to organizations which sponsor collaborative analytical studies and those who participate in such. There is now considerable interest in avoiding duplication and recognizing a sound basis for the comparison of two or more methods each of which has been validated by collaborative study~~.

The symposium will consider the role and design of collaborative studies. Special emphasis will be placed on the comparison of analytical results, and the interpretation of accuracy, precision and reproducibility. The symposium will be of direct interest to organizations which sponsor collaborative analytical studies and those who participate in such studies.

A set of answers to the writing test

Sentence 2

A new fluidized-bed cracking process was developed to provide greater yields of liquid hydrocarbons.

(length reduced by 19 words)

Sentence 3

The disease was caused by consumption of grain left on the fields during war years.

(length reduced by 10 words, "etiological" replaced)

Sentence 4

This inability to distinguish trace elements in the hair fiber and those from external sources presents a serious problem.

(length reduced by 1 word, "exogenous" and "endogenous" replaced)

Sentence 5

Striking similarities were observed in kidney structure and function between human victims of the Balkan syndrome and pigs suffering from ochratoxin poisoning.

(length reduced by 1 word, "pathology", "porcine", "nephropathy" and "renal" replaced).

Would you like to develop your writing skill by writing for Chemistry International?

Perhaps you are familiar with an area of active chemical research aimed at solving a worldwide problem. It might deal with conversion or storage of energy, recognizing and solving pollution problems, control of insect pests, new pharmaceuticals, or any other chemical topic of international importance.

Maybe you would like to write an article on this topic for *Chemistry International.* You needn't be the world's leading expert. Articles should only discuss important and recent advances, and not attempt a comprehensive review of the subject. Your experience will be most valuable to *select* those developments which are central for the uninformed reader to understand the subject and its significance.

Why not jot down your ideas on a nearby notepad or piece of clean filter paper, and send them to Dr. Martin Gellender, editor *Chemistry International* (IUPAC secretariat, 2-3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK). If the topic you propose is suitable, you'll get the go-ahead to start writing. If you wish, the editor can write the article with your help, (you supply background information, your outlook on the subject and perhaps some photographs to illustrate the article). Before publication of any article, the edited manuscript will be submitted to you for correction of errors, your comments, suggested changes, and approval. Then, wait about 6 weeks while the article refluxes through the publication process. Yield: one article in *Chemistry International.*

OFF THE PRESS

Recent IUPAC publications

Macromolecules: Structural order in polymers and biopolymers

Pure and applied aspects of the structural chemistry of polymers were the focus of the International Symposium on Macromolecules (held 7-12 September 1980 in Florence, Italy), of which the plenary lectures are contained in this volume. The symposium considered structural chemistry of a wide range of polymers and biopolymers: including polypropylene, polynucleotides, lactam polymers, globular proteins and immobilized enzymes.

The plenary lectures are organized into three broad areas: (1) stereospecific polymerization of olefins and diolefins, (2) constitutional and configurational order in synthetic polymers and biopolymers, and (3) polymers tailored to specific purposes. The individual papers consider synthetic aspects, determination of molecular structure, relationships between structure and properties, biomedical applications, photochemical applications, polymers as catalysts, and polymers as aids in solving ecological problems.

Edited by Prof. F. Ciardelli and P. Giusti, the 260 page volume cites approximately 800 references. Publication is scheduled for June 1981, and the price of the book will be £26.50 (approximately US$60).

Chemical Indices and Mechanisms of Organ-Directed Toxicity

This book contains the proceedings of the Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, held in Barcelona (Spain) on 4-7 March 1981. The plenary lectures are concerned with drug-related toxic effects, but also include relevant studies of environmental and occupational xenobiotics. They discuss in detail the important organs which may be targets for toxic compounds, such as the liver, kidneys, lungs, blood and nervous system. The book is likely to be of special interest to pharmacologists, toxicologists, medical researchers, clinical chemists and biochemists.

The 270-page volume, edited by Drs. S. S. Brown and D. S. Davies, is scheduled for publication in June 1981 at a cost of £27 (or about US$65).

Nickel toxicology

The 2nd International Conference on Nickel Toxicology was held in Wales in September 1980 under the auspices of the IUPAC Commission on Toxicology, its Subcommittee on Environmental & Occupational Toxicology of Nickel and the Association of Clinical Chemists. This book contains the proceedings of that conference. It is edited by Drs. Stanley S. Brown and F. William Sunderman Jr., the Vice-chairman and Chairman of the Commission on Toxicology.

The 43 papers consider statistical studies of mortality among workers in nickel refineries, electroplating facilities and manufacturing plants using nickel compounds; experimental studies on nickel carcinogenesis; investigations of the uptake, distribution and excretion of nickel in animals and humans; pharmacologic effects of nickel; and analytical analysis of nickel in biological samples. In addition, the 193-page hardcover volume contains the Opening Address presented by Richard Doll, "Relevance of Epidemiology to Policies for the Prevention of Cancer", a foreword by Dr. F. W. Sunderman Jr., an address list of participants, and author and subject index.

The volume may be purchased for £15 from Academic Press Inc (London) Ltd, 24/28 Oval Road, London NW1 in the UK, or for US$36 from Academic Press Inc, 111 Fifth Avenue, New York, New York 10003 in the USA.

Can chemical terminology catch up with 200 years of scientific progress?

Nearly two centuries after Lavoisier recognized the close relationship between comprehension of science and the terminology by which it is communicated, the first major efforts have begun to introduce a comprehensive system for naming chemical transformations and reactions. While great strides have been made in standardizing the naming of chemical *compounds,* there has been almost no progress (and almost no effort) towards establishing uniform terminology for chemical *reactions* and *mechanisms.*

"The impossibility of separating the nomenclature of science from the science itself, is owing to this, that every branch of physical science must consist of three things; the series of facts which are the objects of science, the ideas which represent these facts, and the words by which these ideas are expressed. . . As ideas are preserved and communicated by means of words, it necessarily follows that we cannot improve the language of any science without at the same time improving the science itself; neither can we, on the other hand, improve a science without improving the language or nomenclature which belongs to it."

A. L. Lavoisier, 1780*

Except for a few specialized types of reactions, chemical reactions are presently described by the names of their discoverers (Diels-Alder and Wurtz reactions, for example), inconsistent descriptive terms, sometimes only as an equation, or cumbersome multi-word terms. This unwieldly system of nomenclature, as Lavoisier would have noted with regret, has lagged far behind present understanding of chemical reactions and mechanisms.

Correcting this imbalance is the aim of the series of projects being undertaken by the IUPAC Commission on Physical Organic Chemistry. The spearhead of the Commission's efforts is a system for naming straightforward chemical transformations, introduced in a report prepared by the Commission's chairman, Prof. J. F. Bunnett, and published in the IUPAC journal *Pure & Applied Chemistry* (January 1981). The system stems from a few basic concepts proposed by Prof. Bunnett in 1954, and widely adopted by physical organic chemists for naming substitution reactions. The IUPAC Commission has extended the original concepts to encompass a wide range of chemical reactions. Initially, they have restricted their scope to straightforward transformations involving addition, elimination or substitution of a chemical group on a 'substrate' molecule. Such transformations may involve configurational changes, but are not accompanied by molecular rearrangement. Chemical transformations that are not so straightforward (such as replacement of a divalent group by a divalent group, and ring-closure) will be dealt with in a subsequent report.

The naming of transformations, as the Commission states in the preamble to its report, should be

distinguished from the naming of reactions. The name of a reaction must state or imply all the reactants used and all the products formed. In naming a transformation, on the other hand, one is usually concerned only with changes in the substrate molecule. Thus 'nitration' refers to a process in which a hydrogen atom of a substrate is replaced by a nitro group, irrespective of whether the nitrating reagent is HNO_3, N_2O_5, $NO_2^+BF_4^-$ or $C_2H_5ONO_2$.

Nitration of benzene is a simple example of a *substitution* transformation. As in all substitution reactions, there is an entering group (NO_2) and a leaving group (hydrogen). The proposed name for any simple substitution consists of the name of the entering group, followed by a hyphen (-), the syllable 'de', the name of the leaving group, and the suffix 'ation'. In this example, the transformation may be termed 'nitrodehydrogenation of benzene'. However, hydrogen need not be included in the name if it is an entering or leaving group. When it is omitted, the conventional term 'nitration of benzene' remains.

In most reactions, like the nitration of benzene or iodo-de-diazoniation of benzene diazonium chloride, it will be obvious which molecule is considered the 'substrate'. But this is not always so. The reaction of aniline with benzoyl chloride (to form N-phenylbenzamide) can—with equal validity—be viewed as the replacement of the chlorine atom of benzoyl chloride by an aniline group, or replacement of a hydrogen atom of aniline by a benzoyl group. Thus, this reaction can correctly be named as *either* anilinodechlorination of benzoyl chloride *or* benzoylation of aniline.

Even when the reaction has an obvious substrate, additional information is sometimes needed to specify a reaction uniquely: the site of substitution in the substrate molecule, the stereochemistry involved, or even the probable mechanism.

Although it is not required to specify the reaction mechanism (if it is known), the naming of a transformation should be *consistent* with knowledge of which bonds actually break or form during the reaction. Hydration of the cyano group of benzonitrile (to form benzamide), for example, does *not* involve replacement of the cyano group by a carboxamide group. It should therefore not be named as a substitution transformation, but rather, as an addition reaction.

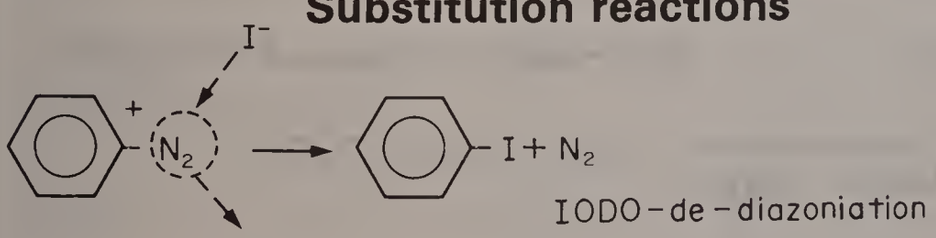
A simple example of an *addition* is the reaction of hypochlorous acid with an alkene. Here, two univalent atoms or groups (a chlorine atom and hydroxyl group) become attached to the unsaturated site in the substrate molecule. The name of this transformation includes only the two adding groups and the suffix 'addition'. Thus, it is called 'hydroxy-chloro-addition'.

The addition of water to a nitrile (such as benzonitrile) to form a carboxylic amide is a slightly more complicated case. It is a divalent addition, and as such, its naming has been the concern of a Working Party chaired by Dr. R. A. Y. Jones of the University of East Anglia (UK). The name of this transformation must indicate that two hydrogens attach to the nitrogen atom of the carbon-nitrogen bond, and that oxygen attaches to the carbon atom. The process is called '*NN*-dihydro-*C*-oxo-biaddition'. The extra syllable 'bi' emphasizes that two univalent groups or one divalent group attach to each terminus of the multiple bond.

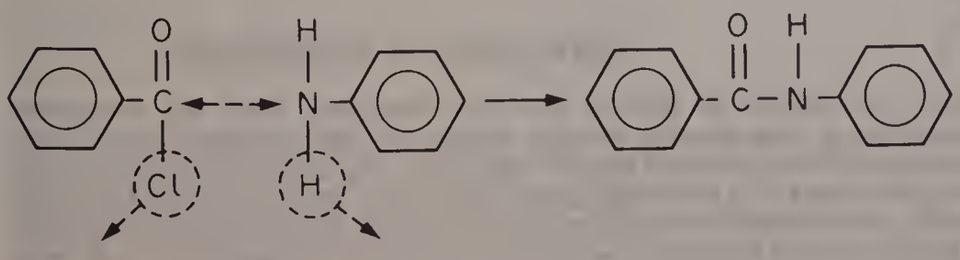
Closely analogous rules are applied for naming *elimination* transformations in which two univalent atoms or groups are detached from the substrate. The two leaving groups may be situated on adjacent carbon atoms of the molecular backbone. In this case, a carbon-carbon double bond, carbonyl group or imine is formed. It is also possible that leaving groups become detached from positions separated by one atom (forming reaction intermediates), or more than one atom. As in addition reactions, the position of detachment is indicated in the name of the transformation. The stereochemistry of the reaction may be described by the term 'sym' or 'anti', showing whether the detaching groups were originally situated on the same side or opposite sides of a reference plane (that is, located cis or trans relative to the other).

The system of naming straightforward transformations is intended to satisfy the need for short, pronounceable and distinctive terms for use in speech and writing. It is hoped that they will be easily

Substitution reactions



IODO-de-diazoniation

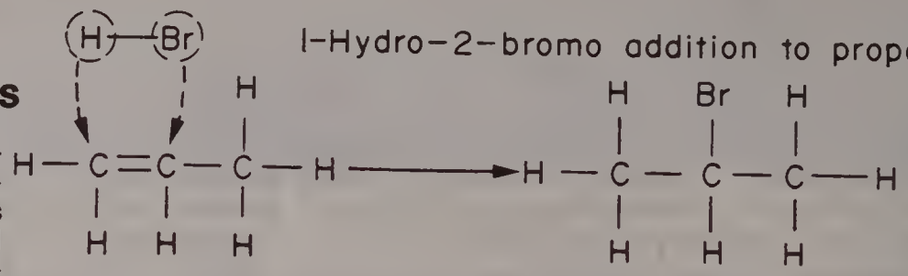


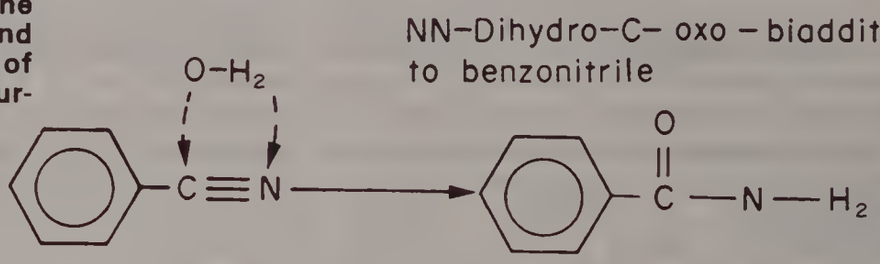
Benzoylation of aniline, *or*
anilino-dechlorination of benzoyl chloride

In all straightforward substitution transformations, there is a univalent entering group and a univalent leaving group. The name of the transformation identifies the entering and leaving group (except if one group is a hydrogen atom, which may be omitted from the name). In most cases, it is very apparent which reacting species should be considered the entering group and which is the substrate. For transformations in which the two are not easily distinguished, two names are possible.

Addition reactions

Simple addition transformations involve the attachment of two univalent atoms or groups to an unsaturated site in the substrate molecule. The name of the transformation indentifies the two adding groups, and specifies their position of attachment at the unsaturated site.





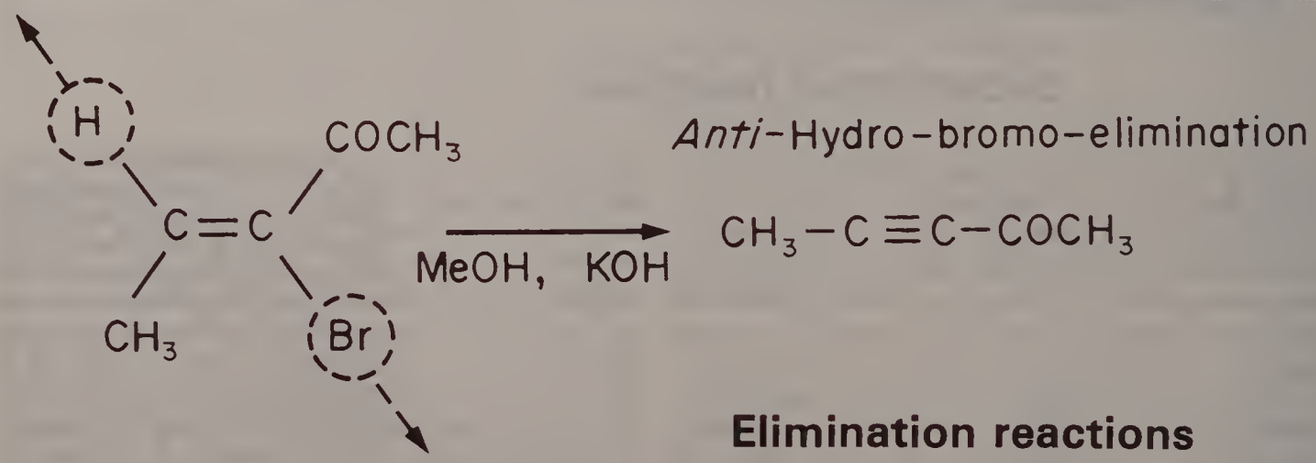
adopted into other major languages of science. In fact, the Commission is soliciting comments on the provisional system of naming straightforward transformations from all chemists, but is especially receptive to viewpoints of chemists whose native language is not English.

As well as spoken and written names, there is also a need for systematic names for indexing and retrieval of information about chemical reactions. This imposes quite different requirements on the naming system. For indexing, names must be distinctive and precise; it is not essential that they be short, simple, easy to pronounce, or avoid punctuation marks or interposed letters and numbers.

The system of straightforward transformations advanced by the Commission on Physical Organic Chemistry suits both sets of requirements. It provides simple spoken names, but can also present very specific descriptions of reactions for computer indexing. It also presents the option of including additional terms to convey the conditions of reaction, reagents employed or presumed reaction mechanism. Names may be inverted for computer storage and retrieval so that similar transformations are indexed together. Thus, 'ethylthio-debromination' becomes 'substitution, ethylthio-debromo' for indexing purposes.

The name of a transformation conveys only the *outcome* of a reaction (what happens when the reaction takes place). It is not intended to show the reaction mechanism (how the reaction takes place). In fact, the method for naming straightforward transformations is only one component of a comprehensive system of terminology for chemical reactions being developed by the Commission.

Related to the naming of chemical transformations—but carried out as an independent project, the Commission is developing a simple method to symbolize reaction mechanisms. Their new terminology will offer far greater versatility than the widely-used



Elimination reactions

In elimination transformations, two atoms or groups become detached from the substrate molecule. In the example shown here, the leaving groups (hydrogen and bromine atoms) are situated on adjacent carbon atoms of the substrate's carbon backbone. To denote that the leaving groups are eliminated from opposite sides of a reference plane, the term "anti" is inserted into the name given for the transformation. A complete description of the reaction, specifying the positions of the leaving groups and the identity of the substrate, would be 4-hydro-3-bromo-elimination from (Z)-3-bromo-3-penten-2-one.

symbols (such as the familiar terms S_N1 and S_N2 introduced by Ingold in the 1950's) which they are intended to replace.

The conventional Ingold notation was introduced about 30 years ago, when interest in reaction mechanisms was rapidly expanding but only a few reaction pathways had been thoroughly explored. Ingold symbols were designed to identify only the type of transformation (using, for example, the symbol 'S' for substitution), distinguish between nucleophilic, electrophilic and homolytic attack; and give the number of molecules involved in the rate-determining step. In this way, a few symbols could accurately describe reaction mechanisms for common types of reactions. The limitations of the Ingold system surfaced as new reaction mechanisms were discovered. Additional terms had to be introduced to modify the original set of symbols (leading to a range of symbols like $S_N2(C+)$ and $S_N1(cA)$. It soon became apparent that the Ingold system was inadequate for dealing with the variety of mechanisms encountered in contemporary chemistry.

In 1960, Prof. Jean Mathieu (now Vice-President of the IUPAC Organic Chemistry Division) suggested that an entirely new system should be introduced to symbolize reaction mechanisms. It should, he felt, deal directly with the basic currency of molecular change: bond making and bond breaking. In this way, a few symbols can be combined to represent an enormous number of possible mechanisms. Such a system would allow chemists to describe, or interpret, reaction mechanisms without referring to tables or long lists of rules.

Prof. Mathieu's proposal has been adopted and developed further by Prof. Robert Guthrie. He formulated a simple system to describe reaction

To demonstrate the simplicity of proposed nomenclature for reaction mechanisms, the Commission on Physical Organic Chemistry presented the basic rules in a set of posters (similar to those shown here) at the 5th IUPAC Conference on Physical Organic Chemistry. With the Commission's proposed nomenclature system, any reaction mechanism can be represented as a combination of only two main symbols: A (representing the formation of a chemical bond) and D (representing the breaking of a bond). The subscript N is used to indicate that the entering or leaving group contributes, or withdraws, both electrons in the chemical bond. The subscript E indicates that the entering or leaving group carries no electrons to, or from, the bond. Bond-making and bond-breaking steps that occur sequentially, one after the other, are separated by a + sign. No + sign is used between steps that occur simultaneously.

Basic symbols of proposed nomenclature for reaction mechanisms

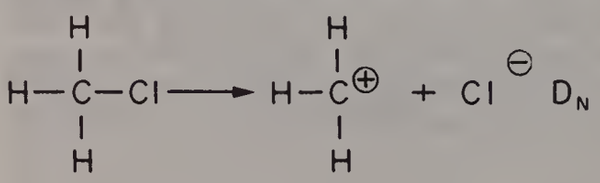
A = Bond-making process

$$Cl^{\cdot} + Cl^{\cdot} \longrightarrow Cl{-}Cl$$

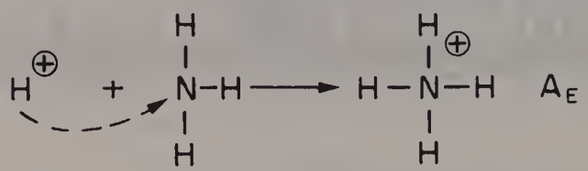
D = Bond-breaking process

$$Br{-}Cl \longrightarrow Br^{\cdot} + Cl^{\cdot}$$

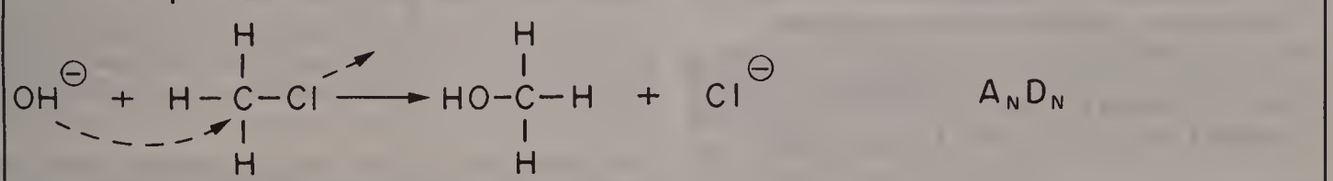
Subscript N = Nucleophile



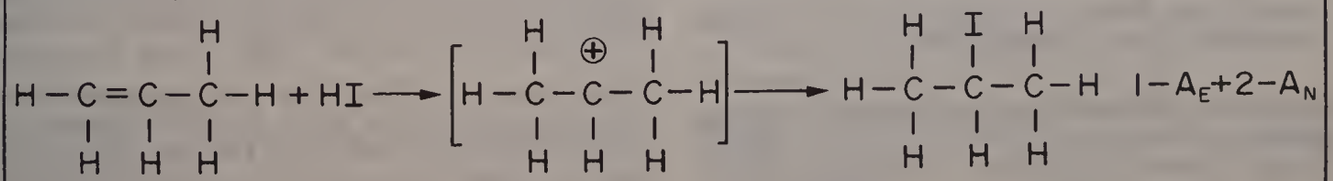
Subscript E = Electrophile



One-step reaction



Two-Step reaction



mechanisms with a few syllables that may easily be communicated through speech and writing. The naming system developed by Prof. Guthrie does not convey information about transition state structure and stereochemistry, but this capacity will likely be added later. Such descriptive detail will be necessary to adapt the system so that the symbols may be indexed, stored and retrieved by computers. A Working Party chaired by Dr. John Littler is studying modifications that will allow reaction mechanisms to be processed by computer.

The system of naming reaction mechanisms utilizes the symbol 'A' to represent addition of an atom or group to the substrate molecule (actually, the term 'A' indicates 'Association', which includes weak-bonding processes as well as formation of a covalent bond). When the adding group carries both electrons that will form the chemical bond, this is indicated by the subscript 'N' (the conventional abbreviation for 'Nucleophilic', or 'nucleus-loving'). Addition of a chemical group contributing no electrons to the bond is denoted by A_E (the subscript 'E' means that the adding group is 'Electrophilic', or 'Electron-loving').

The symbol 'D' represents dissociation of a bond. The dissociation step of a reaction may be D_N or D_E, depending upon whether or not the leaving group has withdrawn electrons from the defunct bond.

If a reaction proceeds in several steps, one following after another, the group of symbols representing each reaction step are separated by a '+' sign. No '+' sign is used when the reaction steps occur simultaneously.

These basic rules are sufficient to write symbols describing most reaction mechanisms. The one-step displacement of a nucleophilic group by another nucleophile becoming attached to the same atom (traditionally designated 'S_N2' according to Ingold notation) is represented as A_ND_N. The advantage of the new naming system becomes apparent when we consider a more complicated reaction, like the detachment of a nucleophilic group from the 1-position of a carbon chain, after which a nucleophile is attached at the 3-position (with a double bond between the carbon atoms in positions 2 and 3). This may simply be represented 1-D_N + 3-A_N.

The basic rules to derive the new mechanism notation are so simple that only about 5 minutes are required to learn them. To demonstrate the simplicity of the system to practicing chemists, the Commission on Physical Organic Chemistry presented a poster display at the 5th IUPAC Conference on Physical Organic Chemistry (held August 1980 in Santa Cruz, California, USA). By discussion of the poster, the Commission also hoped to obtain initial reactions to their proposed terminology for reaction mechanisms (all aspects of the naming system are still under review, and the Commission welcomes comments and suggestions).

By speaking with conference participants, Prof. Guthrie found that—as expected—chemists who had become comfortable with the Ingold system after many years of use are reluctant to change, despite the obvious advantages of the proposed system. The neutral reaction of most conference delegates is probably not a reflection of its real value; the versatility and simplicity of the new method would have greatest and most immediate benefit to students of organic chemistry. The main factor impeding adoption of the new technology thus does not appear to be the small investment of effort required to become proficient in its use, but rather, the hesitation of chemists to relinquish their use of existing notation.

**Quote from "Elements of Chemistry in a New Systematic Order", translated from French by Robert Kerr and published in 1790. (portrait of Lavoisier provided by Conservatoire National Des Arts Et Métiers)*

RECENT REPORTS

Determination of polyunsaturated fatty acids with a cis, cis pentadienoic 1,4 structure.
Determination of polyethylene type polymers.
Standard methods for the analysis of oils, fats & derivatives (6th edition, 1st supplement). Prepared by the Commission on Oils, Fats & Derivatives. *Pure & Applied Chemistry,* 53, No. 3 (March 1981).

Symbolism and Terminology in Chemical Kinetics. Prepared by Keith J. Laidler. *Pure & Applied Chemistry,* 53, No. 3 (March 1981).

Stereochemical Definitions and Notations Relating to Polymers. Prepared by the Commission on Macromolecular Nomenclature. *Pure & Applied Chemistry,* 53, No. 3 (March 1981).

IUPAC Reference Method for **Analysis of Nickel in Serum and Urine** by electrothermal atomic absorption spectrometry. Prepared by the Subcommittee on Environmental and Occupational Toxicology of Nickel. *Pure & Applied Chemistry,* 53, No. 3 (March 1981) pp. 773 - 781.

An evaluation of two simple methods for the Measurement of **Fermenting Power of Baker's Yeast.** Prepared by Prof. F. Parisi for the Commission on Biotechnology. *Pure & Applied Chemistry,* 53, No. 2. (February 1981) pp. 603 - 608.

Nomenclature for Straightforward Transformations (Provisional). Prepared by Prof. J. F. Bunnett for the Commission on Physical Organic Chemistry. *Pure & Applied Chemistry,* 53, No. 1, (January 1981) pp. 306 - 321.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1981

METAL-HYDROGEN SYSTEMS

April 13 - 15 Int. Symposium on Metal Hydrogen Systems. Miami Beach, Florida, USA.
(Dr. T. Nejat Veziroglu, Director of Clean Energy Research Institute, University of Miami, P O Box 248294, Coral Gables, Florida 33124, USA)

ELECTROANALYSIS

April 13 - 16 Int. Symposium on Electroanalysis in Clinical, Environmental and Pharmaceutical Chemistry. Cardiff, UK.
(Electroanalysis Symposium, UWIST, Cardiff, CF1 3NU, UK)

GASOHOL

April 14 - 15 1st European Seminar on The Technical Aspects of Fuel Alcohol Production. Dublin, Ireland.
(Alltechnology Ireland, 23 York Road, Dun Laoghaire, Co. Dublin, Ireland)

CHEMISTRY IN ASIA

April 23 - 25 1st FACS Regional Seminar "Priorities in Chemistry in development of Asia". Kuala Lumpur.
(Hon. Secretary, Malaysian Institute of Chemistry, c/o Rubber Research Institute of Malaysia, P O Box 150, Kuala Lumpur)

CHEMISTRY/ASIA AND PACIFIC

April 26 - May 1 1st Asian & Pacific Chemistry Congress. Singapore.
(The Congress Secretary, 1st ASPAC Congress, Singapore Professional Centre, 129 B Block, Outram Park, Singapore 0316)

POLYMERS

April 29 - 30 International Conference on Polymers, plastics and polyurethanes. Montreal, Canada.
(V.M. Bhatnagar, Alena Enterprises of Canada, P O Box 1779, Cornwall, Ontario K6H 5V7, Canada)

TECHNOLOGY EXCHANGE

April 29 - May 4 TechEx 81—Asia: 9th Annual World Fair for Technology Exchange. Sri Lanka.
(Dr. Dvorkovitz & Associates, P O Box 1748, Ormond Beach, FL 32074, USA)

CLINICAL PHARMACOLOGY

May 11th Int. Symposium on Clinical Pharmacology. Pisa, Italy.
(Prof. Dr. A. Bertelli, via Roma 55, Pisa, Italy)

AGGLOMERATION

May 6 - 9 3rd Int. Symposium on Agglomeration. Nürnberg, Federal Republic of Germany.
(Prof. O. Molerus, Institut fur Mechanische Verfahrenstechnik der Universitat Erlangen, Martenstrasse 9, D-8520 Erlangen, Federal Republic of Germany)

COPPER IN SOILS AND PLANTS

May 7 - 9 Golden Jubilee International Symposium on Copper in Soils and Plants. Perth, Western Australia.
(Prof. J. F. Loneragan, School of Environmental and Life Sciences, Murdoch University, Perth, Western Australia, 6153)

COORDINATION CHEMISTRY

May 10 - 14 10th Meeting of the Coordination and Metal Organic Chemistry Division of the Royal Australian Chemical Institute and the New Zealand Institute of Chemistry. Queenstown, New Zealand.
(Dr. J. Simpson, Department of Chemistry, University of Otago, P O Box 56, Dunedin, NZ)

LIQUID CHROMATOGRAPHY

May 11 - 15 5th Int. Symposium on Column Liquid Chromatography. Avignon, France.
(G. Guiochon, Ecole Polytechnique, Laboratoire de Chimie Analytique Physique, Route de Saclay, 91128 Palaiseau Cedex, France)

SCIENCE/PACIFIC REGION

May 11 - 15 51st Congress of the Australian & New Zealand Association for the Advancement of Science. Brisbane, Queensland, Australia.
(N. Verney, ANZAAS-Queensland, GPO Box 2434, Brisbane, Queensland 4001, Australia)

TRACE ELEMENT METABOLISM

May 11 - 15 4th Int. Conference on the Trace Element Metabolism in Man and Animals. Perth, Australia.
(Prof. Underwood, Univ. of Western Australia, Perth, W.A. Australia 6000)

CHEMICAL EDUCATION/AUSTRALIA

May 13 - 15 National Symposium on "The 1980's: A Challenge and Responsibility for Chemical Education. Bathurst, N.S.W. Australia.
(Mr. C. Fogliani, Secretary, Chemical Education Division, RACI., C/- Science Department, Mitchell College of Advanced Education, Bathurst, N.S.W. 2795, Australia)

HETEROGENEOUS & HOMOGENEOUS CATALYSIS

May 25 - 27 3rd Int. Symposium on Relations between Heterogeneous and Homogeneous Catalysis. Groningen, Netherlands.
(Dr. R. S. Downing, Koninklijke/Shell-Laboratorium, Postbus 3003, NL-1003 AA Amsterdam, Netherlands)

CHEMISTRY/CANADA

May 31 - June 3 64th Chemical Conference and Exhibition of the Chemical Institute of Canada. Includes a symposium on "Coal—Phoenix of the 1980s". Halifax, Nova Scotia, Canada.
(The Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

ACTIVATION ANALYSIS

May 31 - June 4 6th Int. Conference on Modern Trends in Activation Analysis. Toronto, Ontario, Canada.
(Dr. R. E. Jervis, 6th MTAA Conference Convenor, Faculty of Applied Science and Engineering, University of Toronto, Ontario, Canada M5S 1A4)

MINERALOGY

June Int. Conf. on Applied Mineralogy in the Mineral Industry. Johannesburg, South Africa.
(The Secretary, ICAM 81, Private Bag X3015, Randburg, 2125, South Africa)

MOLECULAR BEAMS

June 1 - 5 8th International Symposium on Molecular Beams. Cannes, France.
(Dr. F. M. Devienne, Laboratoire de Physique Moleculaire des Hautes Energies, B P No. 2, F-06530 Peymeinade, France)

ORGANIC CHEMISTRY

June 1 - 5 2nd European Symposium on Organic Chemistry. Stresa, Italy.
(Prof. Giorgio Modena, Istituto di Chimica Organica, Via Marzolo 1, 35 100 Padova, Italy)

PHOSPHORUS CHEMISTRY

June 1 - 5 Int. Conference on Phosphorus Chemistry. North Carolina, USA.
(Prof. Louis D. Quin, General Chairman, Paul M. Gross Chemical Laboratory, Duke University, Durham, NC 27706, USA)

FREE RADICALS

June 2 - 7 15th Int. Symposium on Free Radicals. Canada.
(Prof. W. E. Jones. Dept. of Chemistry, Dalhousie University, Halifax, Nova Scotia B3H 4T3, Canada)

FOOD TECHNOLOGY

June 3 - 5 European Symposium on Progress in Food Engineering. Milan, Italy.
(Simpsio "Progress in Food Engineering", Istituto di Tecnologie Alimentari, Via Celoria 2, 20133 Milan, Italy)

ENERGY & COMPOSITE MATERIALS

June 3 - 5 2nd Int. Symposium on Energy & Composite Materials. Venice, Italy.
(G. Bonavent, Institut Français de Petrole, 1&4 avenue de Bais-Preau, BP 311, F-92506 Rueil Malmaison Cedex, France)

MEASUREMENT OF FUNDAMENTAL CONSTANTS

June 8 - 12 2nd International Conference on Precision Measurement and Fundamental Constants. Maryland, USA.
(Dr. Barry N. Taylor, National Bureau of Standards, Building 220, Room B258, Washington DC 20234, USA)

RUBBER CONFERENCE AND EXHIBITION

June 8 - 12 1981 Int. Rubber Conference and Exhibition. Harrogate, UK.
(RUBBERCON'81, Richard H. Craven, Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, UK)

WOOD AND PULPING CHEMISTRY

June 9 - 12 The "Ekman-days" Int. Symposium on Wood and Pulping Chemistry. Stockholm, Sweden.
(Dr. P. F. Nelson, Australian Paper Manufactures Ltd., Research Laboratory, 17 Rex Ave., Alphington, Victoria 3078, Australia)

TEXTILES AND DYES

June 11 - 13 12th Congress of the International Federation of Associations of Textile Chemists and Colourists: The Future of the Textile Industry. Budapest, Hungary.
(The General Secretary, SODAC, P O Box 244, Bradford, West Yorks, BD1 2JB, UK)

QUANTUM CHEMISTRY

June 14 - 19 4th Int. Congress on Quantum Chemistry. Topic: Quantum mechanical methods. Uppsala, Sweden.
(Per-Olov Löwdin, 4th ICQC, Box 518, S-751 20 Uppsala, Sweden)

RADIATION CURING OF POLYMERS

June 15 - 17 Conference on Radiation Processing for Plastics and Rubber, Cobham, UK.
(J.N. Ratcliffe, The Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, UK)

MODERN TRENDS

June 15 - 19 International Conference "Modern Trends in Activation Analysis". Toronto, Canada.
(Dr. R. E. Jarvis, Chairman, 6th Modern Trends Conference, Department of Chemical Engineering, University of Toronto, Toronto M5S 1A4, Canada)

THERMOPHYSICAL PROPERTIES

June 15 - 19 International Joint Conference on Thermophysical Properties/NBS. Gaithersburg, Maryland, USA.
(A. Cezairliyan, 124 Hazards Building, National Bureau of Standards, Washington DC 20234, USA)

CHROMATOGRAPHY IN BIOCHEMICAL RESEARCH

June 16 - 17 1st International Symposium on Chromatography in Biochemistry, Medicine and Environmental Research. Venice, Italy.
(Italian Group for Mass Spectroscopy in Biochemistry and Medicine, Via Eritrea 62, 20157 Milano, Italy)

MASS SPECTROMETRY IN BIOCHEMICAL RESEARCH

June 18 - 19 8th International Symposium on Mass Spectrometry in Biochemistry, Medicine and Environmental Research. Venice, Italy.
(Italian Group for Mass Spectroscopy in Biochemistry and Medicine, Via Eritrea 62, 20157 Milano, Italy)

AFFINITY CHROMATOGRAPHY
June 22 - 26 4th International Symposium on Affinity Chromatography and Related Techniques. Nijmegen, The Netherlands.
(Dr. T. C. J. Gribnau, Organon Scientific Development Group, P O Box 20, 5340 BH Oss, The Netherlands)

RUBBER & PLASTICS
June 25 - 26 International Conference on Rubber and Plastics. Copenhagen, Denmark.
(V. M. Bhatnagar, Alena Enterprises of Canada, P O Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

BIOELECTROCHEMISTRY & BIOENERGETICS
June 17 - July 2 6th International Symposium on Bioelectrochemistry and Bioenergetics. Kibbuts Kiryat Anarin, Israel.
(Mrs. R. Goldstein, Aharon Katzir Katchalsky Centre of the Institute of Science, Rehovot, Israel)

INSECT CONTROL
June 29 - July 3 International Symposium on the Use of Radiation in Genetic Insect Control. Neuherberg, Federal Republic of Germany.
(Mr. Robert Najar, Conference Service Section, Int. Atomic Energy Agency, P O Box 100, A-1400, Vienna, Austria)

IONS AND PLASMAS
June 30 - July 2 International Conference on Ion and Plasma Assisted Techniques. Amsterdam, The Netherlands.
(CEP Consultants, 26 Albany Street, Edinburgh EH1 3QH, UK)

SURFACE AND COLLOID SCIENCE
July 5 - 10 4th Int. Conference on Surface and Colloid Science. Jerusalem, Israel.
(Prof. A. S. Kertes, Institute of Chemistry, The Hebrew University, Jerusalem, Israel)

MACROMOLECULAR CHEMISTRY
July 6 - 9 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, 1er Étage, Université Pierre et Marie Curie, 4 Place Jussieu, F - 75230 Paris Cédex 05, France)

NMR SPECTROSCOPY
July 12 - 17 5th Int. Meeting on NMR Spectroscopy. Exeter, UK.
(Dr. John F. Gibson, Secretary (Scientific), The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK)

MÖSSBAUER EFFECT
July 13 - 17 Int. Conference on the Application of the Mössbauer Effect. Srinagar, Kashmir, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi - 110012, India)

POLYMER CHARACTERIZATION
July 13 - 17 Int. Symposium on Advances in Polymer Characterization. Durham, UK.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK)

ELECTRON MICROSCOPY & X-RAY DIFFRACTION
July 14 - 16 International Symposium on Microscopy & X-Ray Diffraction, Cambridge, UK.
(McCrone Research Institute Limited, 2 McCrone Mews, Belsize Lane, London NW3 5BG, UK)

IONIZED GASES
July 14 - 18 15th International Conference on Phenomena in Ionized Gases. Minsk, USSR.
(Organizing Committee of ICPIG-15, Institute of Physics, USSR Academy of Sciences, Leninsky Prospect 70, Minsk, USSR 220602)

NON-CONVENTIONAL ENERGY SOURCES
July 14 - Aug. 6 2nd International Symposium on Non-conventional Energy. Topics include solar energy fundamentals, advanced solar energy technology, bioconversion, materials science for solar energy conversion and management of energy. Miramare-Trieste, Italy.
(International Centre for Theoretical Physics, P O Box 586, I-34100 Triest, Italy)

CHEMOTHERAPY
July 19 - 24 12th Int. Congress of Chemotherapy. Florence, Italy.
(Prof. Dr. P. Periti, Viale Morgagni 65, 1-50134 Florence, Italy)

PHARMACOLOGY
July 19 - 24 8th Congress of the Int. Union of Pharmacology. Tokyo, Japan.
(Dr. F. Gross, Dept., of Pharmacology, University of Heidelberg, Im Neuenheimer Feld 366, D - 6900 Heidelberg, Federal Republic of Germany)

PLATINUM GROUP METALS
July 19 - 24 Int. Conference on the Chemistry of the Platinum Group Metals. Bristol, UK.
(Dr. P. L. Goggin, School of Chemistry, The University, Bristol BS8 1TS, UK)

VAPOUR GROWTH OF CRYSTALS
July 19 - 24 5th International Conference on Vapour Growth and Epitoxy. San Diego, Calif., USA.
(Dr. D. W. Shaw, Texas Instruments, POB 225936, M/S 145, Dallas, Texas 75265, USA)

DETERMINATION OF POLYMER STRUCTURE
July 20 - 23 22nd Prague Microsymposium on Characterization of Dynamic & Geometrical Structure of Polymer Systems by NMR Spectra. Prague, Czechoslovakia.
(B. Sedlácek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Science, Heyrovského N.2, CS-162 06 Praha 616, Czechoslovakia)

ORGANIC SYNTHESIS
July 20 - 23 7th Int. Symposium on Synthesis in Organic Chemistry. Oxford, UK.
(Dr. John F. Gibson, The Royal Society of Chemistry. Burlington House, London W1V 0BN, UK)

CAROTENOIDS
July 26 - 31 6th Int. Symposium on Carotenoids. Liverpool, UK.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, P O Box 147, Liverpool L69 3BX, UK)

BIOPHYSICS
August 7th Congress of the Int. Union of Pure & Applied Biophysics. Mexico City, Mexico.
(Dr. K. Wuthrich, Institute of Molecular Biology & Biophysics, ETH, CH-8049 Zürich, Switzerland)

ENERGY SOURCES
August United Nations Conf. on New & Renewable Sources of Energy. Nairobi, Kenya.
(Information Officer, DESI/DPI - room 1072-C, United Nations, New York, NY 10017, USA)

ORGANOMETALLIC CHEMISTRY

August 2 - 6 Int. Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, Colorado, USA.
(Prof. J. K. Stille, Dept., of Chemistry, Colorado State University, Fort Collins, CO 80523, USA)

CHEMICAL EDUCATION

August 9 - 14 6th Int. Conference on Chemical Education. Maryland, USA.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington DC 20550, USA)

ORGANOMETALLIC CHEMISTRY

August 9 - 14 10th Int. Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

PLASMA CHEMISTRY

August 10 - 14 5th Int. Symposium on Plasma Chemistry. Edinburgh, UK.
(Dr. B. Waldie, Chairman, Department of Chemical and Process Engineering, Heriot-Watt University, Chambers Street, Edinburgh EH1 1HX, UK)

IUPAC CONGRESS

August 16 - 22 28th IUPAC Congress. Topics are: chemistry applied to energy problems, environment, upgrading of resources, computers, analytical chemistry, physical chemistry, inorganic chemistry, organic chemistry. Vancouver, Canada.
(IUPAC Congress Secretariat, c/o Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

NUTRITION

August 16 - 22 12th International Congress of Nutrition. San Diego, California, USA.
(Dr. Max Milner, Executive Secretary, American Institute of Nutrition, 9650 Rockville Pike, Bethesda, Maryland 20014, USA)

CRYSTALLOGRAPHY

August 16 - 25 12th Int. Congress of Crystallography. Ottawa, Canada.
(Mr. K. Charbonneau, Executive Secretary, 12th IUCr Congress, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6)

ATMOSPHERIC PHYSICS

August 17 - 21 3rd Scientific Assembly of the International Association of Meteorology and Atmospheric Physics. Hamburg, Federal Republic of Germany.
(S. Ruttenberg, Secretary General, IAMAP, NCAR, P O Box 3000, Boulder, CO 80307, USA)

HIGH PRESSURE

August 17 - 22 8th AIRAPT, 18th EHPRG Conference on High Pressure in Research and Industry. Uppsala, Sweden.
(Dr. Carl-Magnus Backman, Secretary, High Pressure in Research and Industry, 8th AIRAPT & 18th EHPRG Conference, Institute of Physical Chemistry, P O Box 532, S-751 21 Uppsala, Sweden)

ANALYTICAL STUDIES

August 20 - 21 Int. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford St., London SE1 9NQ, UK)

AMERICAN CHEMICAL SOCIETY

August 23 - 28 ACS Fall Meeting. New York City, USA.
(American Chemical Society, 1155 16th Street, NW, Washington DC 20036, USA)

CHEMISTRY/NEW ZEALAND

August 23 - 28 Golden Jubilee Conference of New Zealand Institute of Chemistry. Auckland, New Zealand.
(Dr. D. J. McLennan, Chemistry Dept., University of Auckland, New Zealand)

EUROANALYSIS

August 23 - 28 4th FECS Euroanalysis Conference. Helsinki, Finland.
(Euroanalysis—IV, Association of Finnish Chemical Societies, Mr. Veikko Velamo, Executive Director, Pohj. Hesperiankatu 3 B 10, SF-00260 Helsinki 26, Finland)

HETEROCYCLIC CONGRESS

August 23 - 28 8th International Congress of Heterocyclic Chemistry. Graz, Austria.
(Prof. Dr. Thomas Kappe, Institute of Organic Chemistry, University of Graz, Heinrichstr. 28, A-8010 Graz, Austria)

SOLAR ENERGY

August 23 - 28 Solar World Forum: Int. Solar Energy Society Congress & Exhibition. Brighton, UK.
(The Administrator UK + ISES, 19 Abermarle St., London W1X 3HA, England)

BIOCHEMISTRY/BIOPHYSICS

August 23 - 29 7th Int. Biophysics Congress and 3rd Panamerican Biochemistry Congress. Mexico City.
(Dr. Hugo Arechiga, Cerrada de Popocatepetl 51-A, Colonia General Anaya, Mexico 13, D.F., Mexico)

ORGANOSILICON CHEMISTRY

August 23 - 29 6th Int. Symposium on Organosilicon Chemistry. Budapest, Hungary.
(Prof. Tamás Székely, Chairman of the Organizing Committee, Research Laboratory of Inorganic Chemistry of the Hungarian Academy of Sciences, H-1502 Budapest, Pf. 132, Hungary)

DRUG RESEARCH

August 25 - 28 2nd IUPAC-IUPHAR Symposium on Strategy in Drug Research. Noordwijkerhout, Netherlands.
(Symposium Secretary, Dr. M. L. de Winter, Philips Duphar B.V., P O Box 2, NL-1380 AA Weesp, Netherlands)

IUPAC GENERAL ASSEMBLY

Aug. 25 - Sept. 2 31st IUPAC General Assembly. Leuven, Belgium.
(IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK)

HISTORY OF SCIENCE

Aug. 26 - Sept. 3 16th Int. Congress of the History of Science. Bucharest, Romania.
(S. Balan, Romanian Academy of Science, Calea Victoriei 125, Set 1, Bucharest, Romania)

ENVIRONMENTAL POLLUTION
Aug. 30 - Sept. 1 Scientific Meeting on Environmental Pollution in the Mediterranean. Athens, Greece.
(Dr. E. Lahaniatis, Georgenstr. 78, 8 Munich 40, Federal Republic of Germany)

AROMATIC COMPOUNDS
Aug. 30 - Sept. 4 4th Int. Symposium on Chemistry of Novel Aromatic Compounds. Jerusalem, Israel. (Prof. I. Agranat, Department of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

ORGANIC CHEMISTRY
Aug. 30 - Sept. 4 22nd Meeting Groupe d'Étude de Chimie Organique. Saint-Maximin, France.
(Prof. G. Descotes, Laboratoire de Chimie Organique 2, École Supérieure de Chimie Industrielle de Lyon, 43 Bd du 11 Novembre 1918, F-69622 Villeurbanne Cedex, France)

CLINICAL CHEMISTRY
Aug. 30 - Sept. 5 11th Int. Congress of Clinical Chemistry. Vienna, Austria.
(Secretariat, 11th Int. Congress of Clinical Chemistry. 4th European Congress of Clinical Chemistry, P O Box 35, A-1095 Wien, Austria)

HETEROCYCLIC COMPOUNDS
Aug. 31 - Sept. 3 7th Symposium on Chemistry of Heterocyclic Compounds. Bratislava, Czechoslovakia.
(Secretariat, Symposium on Chemistry of Heterocyclic Compounds, Department of Organic Chemistry, Slovak Technical University, CS-880 37 Bratislava, Czechoslovakia)

FERMENTATION TECHNOLOGY
Aug. 31 - Sept. 3 3rd Int. Conference on Computer Applications in Fermentation Technology. Manchester, UK.
(Conference Secretariat, Society of Chemical Industry, 14 Belgrave Square, London SW1X 8PS, UK)

CHEMICAL ENGINEERING
Aug. 31 - Sept. 4 CHISA '81, 7th International Congress of Chemical Engineering, Chemical Equipment Design and Automation. Prague, Czechoslovakia.
(7th Congress CHISA '81, P O Box 857, CS 111 21 Praha 1, Czechoslovakia)

ORGANIC FREE RADICALS
Aug. 31 - Sept. 4 3rd Int. Symposium on Organic Free Radicals. Freiburg, Federal Republic of Germany.
(GDCh, Box 90 04 40, D-6000 Frankfurt 90, Federal Republic of Germany)

FOOD SCIENCE
September Symposium on the Role of Food Science in the Community (Int. Union of Food Science & Technology). Helsinki, Finland.
(Prof. P. Koivistoinen, Institute of Food Chemistry and Technology, Helsinki, Finland)

HEAVY METALS
September International Conference on Heavy Metals in the environment. Amsterdam, Netherlands.
(Secretariat, CEP Consultants Ltd., 26 Albany St., Edinburgh EH1 3QH, Scotland, UK)

HOT ATOM CHEMISTRY
September 11th International Hot Atom Chemistry Symposium. Davis, California, USA.
(Prof. J. Root, Department of Chemistry, University of California, Davis, California 95616, USA)

OCCUPATIONAL HEALTH
September 20th International Congress on Occupational Health. Cairo, Egypt.
(Prof. Dr. M. Hassanein, 32 Falaki Street, Cairo, Egypt)

CHROMATOGRAPHY
September 1 - 4 3rd Danube Symposium on Chromatography. Siófok, Hungary.
(3rd Danube Symposium on Chromatography, c/o Hungarian Chemical Society, P O Box 240, H-1368 Budapest, Hungary)

ATOMIC SPECTROSCOPY
September 4 - 8 9th Int. Conference on Atomic Spectroscopy and 22nd Colloquium Spectroscopicum Internationale. Tokyo, Japan.
(The Japan Society for Analytical Chemistry, 9th ICAS/XXII CSI, Gotanda Sanhaitsu, 26-2 Nishigotanda 1-chome, Shinagawa-ku, Tokyo 141, Japan)

CLINICAL ENZYMOLOGY
September 6 - 9 3rd International Congress on Clinical Enzymology. Salzburg, Austria.
(The Secretariat, III Congress for Clinical Enzymology, P O Box 105, A-1014 Wien, Austria)

METALLIC CORROSION
September 6 - 11 8th Int. Congress on Metallic Corrosion (ICMC). Mainz, Federal Republic of Germany.
(DECHEMA, 8th ICMC, Postfach 97 01 46, D-6000 Frankfurt/Main 97, Federal Republic of Germany)

PHOTOCHEMISTRY
September 6 - 11 10th Int. Conference on Photochemistry. Crete, Greece.
(Dr. P. M. Rentzepis, Bell Laboratories, ID 358, Murray Hill, New Jersey 07974, USA)

ANAEROBIC DIGESTION
September 6 - 12 2nd Int. Symposium on Anaerobic Digestion. Travemünde, Federal Republic of Germany.
(2nd International Symposium on Anaerobic Digestion, 142 - 144 Oxford Road, Cowley, Oxford, UK)

EXPLOITATION OF OUTER SPACE
September 6 - 12 32nd International Astronautical Congress, Rome, Italy.
(International Astronautical Federation, 250 Rue Saint-Jacques, 75005 Paris, France)

MATERIALS AT HIGH TEMPERATURES
September 7 - 10 The Chemistry of Materials at High Temperatures. A.E.R.E. Harwell, Nr. Didcot, Oxford, UK.
(Dr. P. E. Potter, Chemistry Division, A.E.R.E. Harwell, Didcot, Oxon OX11 0RA, UK)

CHEMISTRY OF CARBOCATIONS
September 7 - 11 Int. Symposium on Chemistry of Carbocations. Bangor, Wales.
(Dr. John F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK)

GAMMA RAY SPECTROSCOPY
Sept. 7 - 11 4th International Symposium on Neutron-Capture Gamma-Ray Spectroscopy and Related Topics. Grenoble, France.
(Prof. Dr. Till von Egidy, Physik-Department E 18, Fakultät für Physik, Technische Universität München, James-Franck-Strasse, D-8046 Garching, Federal Republic of Germany)

MOLECULAR SPECTROSCOPY
September 7 - 11 15th European Congress on Molecular Spectroscopy. Norwich, UK.
(Prof. W. J. Orville-Thomas, Department of Chemistry & Applied Chemistry, University of Salford, Salford M5 4WT, UK)

COMPUTER CONTROL OF CHEMICAL PLANTS
September 8 - 11 14th European Symposium on Computerized Control and Operation of Chemical Plants. Laxenburg, Nr. Vienna.
(CHEM CONTROL 81, c/o Verein Österreichischer Chemiker, Eschenbachgasse 9, A-1010 Wien, Austria)

OLEFIN METATHESIS
Sept. 9 - 11 4th International Symposium on Olefin Metathesis. Belfast, UK.
(Prof. K. J. Ivin, Department of Chemistry, The Queen's University of Belfast, Belfast BT9 5AG, UK)

RADIOPHARMACOLOGY
September 9 - 11 2nd Int. Symposium on Radiopharmacology. Chicago, Illinois, USA.
(Pharmacology Department, School of Medicine, Loyola University, Maywood, Illinois 60653, USA)

ACTINIDES
Sept. 10 - 15 International Conference on Actinides. Pacific Grove, California, USA.
(Dr. Norman Edelstein, Materials and Molecular Research Division, Building 70 A, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720, USA)

MICROSCOPY OF COALS
September 14 - 16 Microscopy of Coals, Cokes, Carbon & Graphite. York, UK.
(Administrator, Royal Microscopial Society, 37/38 St. Clements, Oxford OX4 1AJ, UK)

POLYMER TECHNOLOGY
September 14 - 16 Int. Conference on Developments in Polymer Science and Plastics Technology. Coventry, UK.
(Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, UK)

ADHESION & LUBRICATION
September 14 - 18 34th International meeting of the Société de Chimie Physique on Microscopic Aspects of Adhesion & Lubrication. Paris, France.
(Société de Chimie Physique, 34th Inter. Meeting, Attn. Dr. C. Troyanowsky, Gen. Secretary, 10 rue Vauquelin, F 75005, Paris, France)

HEAVY METALS
September 15 - 18 International Conference on Heavy Metals in the Environment. Amsterdam, The Netherlands.
(CEP Consultants, 26 Albany Street, Edinburgh EH1 3QH, UK)

BIOLOGICALLY-ACTIVE NATURAL PRODUCTS
September 21 - 26 1st International Conference on Chemistry and Biotechnology of Biologically Active Natural Products. Varna, Bulgaria.
(Dr. R. Vlahov, Centre of Phytochemistry and Chemistry of Natural Products, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria)

MACROMOLECULAR PHYSICS
September 21 - 26 12th Europhysics Conference on Macromolecular Physics. Leipzig, German Democratic Republic.
(Organizing Committee, 12th EPS Conference, Karl-Marx-Universität Sektion Physik, Linnéstrasse 5, DDR-7010 Leipzig, Democratic Republic of Germany)

RADIOISOTOPES
Sept. 28 - Oct. 2 International Conference on Industrial Applications of Radioisotopes and Radiation Technology. Grenoble, France.
(Mr. Robert Najar, Conference Service Section, IAEA, P O Box 100, A-1400 Vienna, Austria)

CHEMICAL PHYSICS
Sept. 28 - Oct. 4 Int. Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-b, SU-117334 Moscow, USSR)

BIO-CALORIMETRY
Sept/Oct International Symposium on Bio-Calorimetry. Tbilisi, Georgian SSR, USSR
(Dr. P. G. Asatiani, Institute of Physics, Acad. Sci. GSSR, Guramishvili str. 6, 380077 Tbilisi, USSR)

CLINICAL PHARMACOLOGY
October 11th International Symposium on Clinical Pharmacology. Pisa, Italy.
(Prof. Dr. A. Bertelli, Via Roma 55, I-56100 Pisa, Italy)

CHEMICAL ENGINEERING
October 4 - 9 Interamerican Congress of Chemical Engineering. Montreal, Canada.
(Canadian Society for Chemical Engineering, 151 Slater St., Suite 906, Ottawa, Ontario, Canada K1P 5H3)

WATER POLLUTION CONTROL
October 4 - 10 Water Pollution Control Federation Int. Convention. Detroit, Michigan, USA.
(R. A. Canham, 3900 Wisconsin Avenue, NW, Washington DC 20016, USA)

ENERGY/ASIA
October 7 - 9 ASCOPE 81: 2nd Asian Energy Conference. Manila, Philippines.
(ASCOPE 81, PNOC Building, 7901 Makati Avenue, Makati, Philippines)

CHEMASIA 81
October 21 - 24 2nd Asian International Chemical & Process Engineering & Contacting Show & Conference. World Trade Centre, Singapore.
(John Huang, Singapore Exhibition Services (pte) Ltd. 410 Cathay Building, Mount Sophia, Singapore 0922)

MAGNETOHYDRODYNAMICS
November Int. Conference on Magnetohydrodynamics. Sydney, Australia.
(Conference Manager, The Institute of Engineers Australia, 11 National Circuit, Barton, ACT 2600, Australia)

FUEL CYCLES
November 9 - 12 International Conference on Fast Reactor Fuel Cycles. London, UK.
(The Secretariat, British Nuclear Energy Society at the Institution of Civil Engineers, 1 - 7 Great George Street, Westminster, London SW1P 3AA, UK)

CONFERENCES 1981/82

ENVIRONMENTAL POLLUTION
November 16 - 17 2nd International Symposium on Environmental Pollution. Miami Beach, Florida, USA.
(Alena Enterprises of Canada, P O Box 1779, Cornwall, Ontario K6H 5V7, Canada)

CHROMATOGRAPHY
November 19 - 20 2nd International Chromatography Conference. Miami Beach, Florida, USA.
(Mr. V. M. Bhatnagar, Alena Enterprises of Canada, P O Box 1779, Cornwall, Ontario K6H 5V7, Canada)

CHEMICAL ENGINEERING
November 25-27 2nd Mediterranean Congress on Chemical Engineering. Barcelona, Spain.
(2° Congreso Mediterraneo De Ingenieria Quimica, Expoquimia-81/Congress Secretariat, Plaza España, Barcelona-4, Spain)

ENVIRONMENTAL POLLUTION
December 17 - 18 2nd European Conference on Environmental Pollution. Linz, Austria.
(Alena Enterprises of Canada, P O Box 1779, Cornwall, Ontario K6H 5V7, Canada)

1982

CHEMICAL FEEDSTOCKS FROM COAL
February Int. Symposium "Chem-Coal—A Chemical Feedstock. Johannesburg, South Africa.
(Mr. F. L. D. Cloete, South African Inst. of Chemical Engineers, c/o CERG/CSIR, P O Box 395, Pretoria 0001, South Africa)

CHEMISTRY RELATING TO AGRICULTURE
February 2 - 5 Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington DC 20036, USA)

SAFE USE OF SOLVENTS
March 23 - 27 Int. Symposium on the Safe Use of Solvents. Brighton, UK.
(Mr. S. G. Luxon, Health & Safety Executive, 25 Chapel Street, London NW1 4DT, UK)

AMERICAN CHEMICAL SOCIETY
Mar. 29 - Apr. 2 183rd American Chemical Society National Meeting. Las Vegas, Nevada, USA.
(American Chemical Society, 1155 16th Street, NW, Washington DC 20036, USA)

UK CHEMICAL CONGRESS
Mar. 30 - Apr. 1 Annual Chemical Congress. Birmingham, UK.
(Chemical Society, Burlington House, London W1V 0BN, UK)

POLLUTANT ANALYSIS
April 14 - 16 12th Annual Symposium on the Analytical Chemistry of Pollutants. Amsterdam, The Netherlands.
(Congress Bureau Vrije Universiteit, P O Box 7161, 1007 MC Amsterdam, The Netherlands)

CLINICAL CHEMISTRY
April 19 - 22 International Congress on Automation in Clinical Laboratory. Barcelona, Spain.
(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clinicos, C.S. "Príncipes de Espana", Hospitalet de Llobregat (Barcelona), Spain)

RADICAL POLYMERISATION
May Microsymposium on Radical Polymerisation. Smolenice, Czechoslovakia.
(Dr. E. Borsig, Institute of Polymer Chemistry, SAV, Dúbravska cesta, Bratislava, Czechoslovakia)

SCIENCE/SOUTH PACIFIC
May 52nd ANZAAS Conference. Sydney, Australia.
(ANZAAS, Box 873, GPO Sydney 2001, Australia)

GEOCHEMICAL EXPLORATION
May 12 - 14 9th Geochemical Exploration Symposium. Saskatchewan, Canada.
(V. Sopuck, Saskatchewan Research Council, 30 Campus Drive, Saskatoon, Saskatchewan S7N OX1, Canada)

CATALYSIS
May 26 - 29 8th Canadian Symposium on Catalysis. Waterloo, Ontario, Canada.
(Jana Karger, Symposium Secretary, 8th Canadian Symposium on Catalysis, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1)

MEDICINAL CHEMISTRY
June 20 - 24 Medicinal Chemistry Symposium. Toronto, Canada.
(Leslie Humber, North American Medicinal Chemistry Symposium, c/o Ayerst Laboratories, P O Box 6115, Montreal, Quebec, H3C 3J1, Canada)

SOLUTE-SOLVENT INTERACTIONS
July 5-10 6th Int. Symposium on Solute-Solute-Solvent Interactions. Minoo, Osaka, Japan.
(Prof. H. Otaki, Tokyo Institute of Technology at Nagatsutu, Midori-ku, Yokohama 227, Japan)

PHYSICAL ORGANIC CHEMISTRY
July 11 - 16 6th IUPAC Conference on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, B-1348 Louvain-la-Neuve, Belgium)

MACROMOLECULES
July 12 - 16 IUPAC Macromolecular Symposium. Amherst, Massachusetts, USA.
(James C. W. Chien, Dept. of Polymer Science and Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA)

SELECTIVE POLYMER SORBENTS
July 19 - 22 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.
(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 162 06 Prague 616, Czechoslovakia)

POLYMERIZATION OF HETEROCYCLES
Summer Int. Symposium on Polymerization of Small Heterocycles. Poland.
(Prof. Z. Jedliński, Polish Academy of Sciences, Polymer Institute, P O Box 49, Curie - Sklodowskiej 34, PL - 41 800 Zabrze, Poland)

NATURAL PRODUCTS
August 2 - 7 13th Int. Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs. Jeanne Beck, Symposium Secretariat - S.219, CSIR, P O Box 395, Pretoria 0001, Republic of South Africa)

MARINE CHEMISTRY
August 2 - 13 Joint Oceanographic Assembly. Halifax, Canada.
(Mr. Leo O'Quinn, Executive Secretary, JOA-82, 240 Sparks Street, 7th Floor West, Ottawa, Ontario, K1A 0E6, Canada)

BIOCHEMISTRY
August 15 - 21 Int. Congress of Biochemistry. Perth, Australia.
(Prof. B. N. Preston, Biochemistry Dept., Monash University, Clayton, Victoria 3168, Australia)

COAL CONVERSION
August 16 - 20 International Coal Conversion Conference. Pretoria, South Africa.
(The Symposium Secretariat S.244, International Coal Conversion Conference, Council for Scientific and Industrial Research, P O Box 395, 0001 Pretoria, Republic of South Africa)

ORGANIC SYNTHESIS
August 22 - 27 4th International Conference on Organic Synthesis. Tokyo, Japan.
(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan)

THERMAL ANALYSIS
August 22 - 28 7th International Conference on Thermal Analysis. Kingston, Ontario, Canada.
(Chairman, Organizing Committee, Seventh ICTA, Dunlop Research Centre, Sheridan Park Research Community, Mississauga, Ontario, Canada L5K 1Z8)

COORDINATION CHEMISTRY
August 23 - 27 22nd Int. Conference on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010 Hungary)

INDUSTRIAL MICROORGANISMS
August 23 - 27 4th International Symposium on the Genetics of Industrial Microorganisms. Kyoto, Japan.
(GIM Japan National Committee, c/o Microbiology Research Foundation, 2-4-16 Yayoi, Bunkyo-ku, Tokyo 112, Japan)

PESTICIDE CHEMISTRY
Aug. 29 - Sept. 4 Int. Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan)

PLANT GROWTH
Aug. 29 - Sept. 4 21st International Horticultural Congress. Hamburg, Federal Republic of Germany.
(21st International Horticultural Congress, Hamburg Messe und Congress GmbH, P O Box 30 23 60, D-2000 Hamburg 36, Federal Republic of Germany)

MASS SPECTROMETRY
Aug. 30 - Sept. 3 9th Int. Mass Spectrometry Conference. Vienna, Austria.
(INTERCONVENTION, P O Box 105, A-1014 Vienna, Austria)

MYCOTOXINS AND PHYCOTOXINS
Aug. 31 - Sept. 2 5th Int. Symposium (IUPAC) on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30², DK-2100 Copenhagen 0, Denmark)

TRANSIENT SPECIES
Autumn Euchem Conf. on Short lived species in inorganic chemistry and their stabilization. Federal Republic of Germany.
(GDCh-Geschäftsstelle, Postfach 90 04 40, 6000 Frankfurt/Main 90, Federal Republic of Germany)

THEORETICAL CHEMISTRY
September International Symposium on Theoretical Organic Chemistry. Dubrovnik, Croatia, Yugoslavia.
(Dr. Ante Graovac, Institute "R. Boskovíc", P O Box 1016, 41001 Zagreb, Yugoslavia)

CHEMICAL STRUCTURE-BIOLOGICAL ACTIVITY
September 6 - 9 4th European Symposium on Chemical Structure and Biological Activity: Quantitative Approaches. Bath, UK.
(Dr. J. C. Dearden, School of Pharmacy, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF, UK)

HETEROGENEOUS CATALYSTS
September 6 - 9 3rd Int. Symposium on the Scientific Bases for the Preparation of Heterogeneous Catalysts. Louvain-la-Neuve, Belgium.
(Prof. B. Delmon, Université Catholique de Louvain, Groupe de Physico-Chimie Minerale et de Catalyse, Place Croix du Sud 1, B-1348 Louvain-la-Neuve, Belgium)

HEAT TRANSFER
September 6 - 10 7th International Heat Transfer Conference. Munchen, Federal Republic of Germany.
(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt, Federal Republic of Germany)

AMERICAN CHEMICAL SOCIETY
September 12 - 17 184th National Meeting of the American Chemical Society. Kansas City, Missouri, USA.
(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA)

THERMODYNAMICS—CALORIMETRY
September 13 - 17 2nd Czechoslovak Conference on Calorimetry. Liblice and Prague, Czechoslovakia.
(Prof. Dr. Ing, Jiří Pick, DrSc. Dept. of Physical Chemistry, Institute of Chemical Technology, 166 28 Prague 6, Suchbatarova 5, Czechoslovakia)

CHEMISTRY/ASIA
October 1st FACS Chemical Congress. Kuala Lumpur, Malaysia.
(Dr. Mohinder Singh, Hon. Sec. Institut Kimia Malaysia, c/o Rubber Research Institute of Malaysia, P O Box 150, Kuala Lumpur, Malaysia)

WATER POLLUTION
October Water Pollution Control Federation Int. Convention. Saint Louis, Missouri, USA.
(R. A. Canham, 3900 Wisconsin Avenue NW, Washington DC 20016, USA)

CHEMICAL REACTION ENGINEERING
October 4 - 6 International Symposium "Chemical Reaction Engineering". Boston, Massachusetts, USA.
(Prof. James Wei, Dept. of Chemical Engr. Mass. Inst. of Tech. Cambridge, MA 02139, USA)

Chemistry International

is the news magazine of the

INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY (IUPAC)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

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Chemistry International

IUPAC

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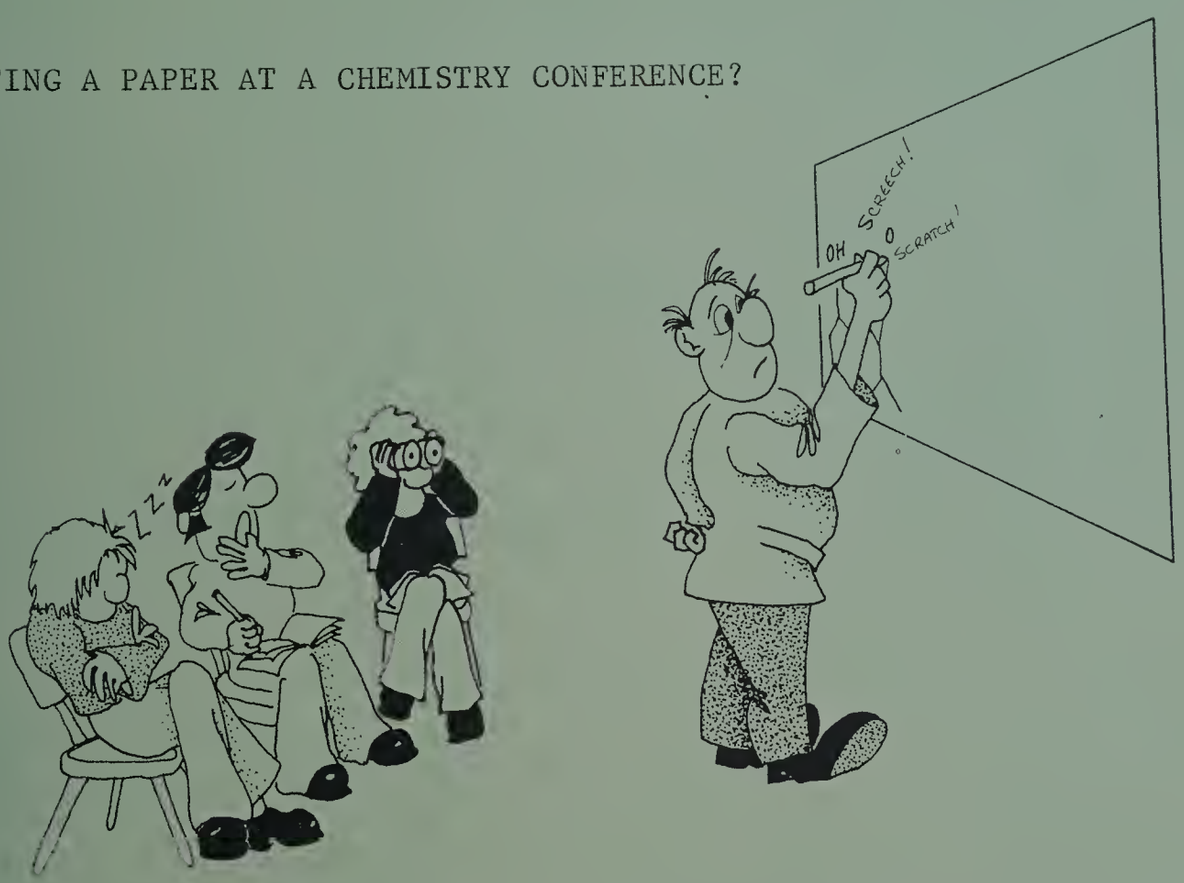
PRESENTING A PAPER AT A CHEMISTRY CONFERENCE?



HOW TO CAPTURE THE ATTENTION OF YOUR AUDIENCE

. . . WITHOUT HOLDING THEM HOSTAGE!

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PROPOSALS FOR ARTICLES

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THE EDITOR'S DESK

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Living with pests

The introduction of DDT in the 1940's enormously expanded the role that chemistry was to perform in the improvement of living and health standards. "Miracle pesticides" promised to usher in an era which was to be nearly free of pestilence and insect-borne disease. Since then, we have come to rely on pesticides to an increasing extent, but it has become clear that these compounds are not the ultimate solution to this age-old affliction. The first organochlorine insecticides achieved dramatic victories in the war against hunger and disease, but mankind's fight against insects has proved to be a never-ending tug-of-war. The introduction of new, more effective pesticides is being matched by the development of insect resistance to pesticide compounds. Some ground has already been lost in the efforts to combat malaria and other insect-borne diseases.

What appears to be gradually emerging is a new attitude towards the control of insect pests, and the crop destruction and disease they cause. The conventional goal of pesticide developers, to find new compounds with ever higher broad-spectrum toxicity, is increasingly being questioned. It is now accepted that, except perhaps for a very few species, insect pests cannot be eradicated. Insects, like man, exhibit a remarkable ability to adapt to new conditions. Even if one insect pest could be eliminated, this would leave vacant an ecological niche to eventually be exploited by equally voracious insects with a higher tolerance to insecticide compounds.

It is reasonable to envision that the next generation of crop protection chemicals will be designed specifically to protect crops; and not necessarily to kill insects. They will be applied only when a genuine need for control measures is indicated by monitoring of insect pest populations. Their application will be carefully controlled and timed to achieve the desired level of pest control—and not indiscriminate insect destruction. They will augment, and not displace, the function of natural insect and bird predators.

The striking feature of this new strategy is that it would no longer pit the interests of pesticide manufacturers directly against those of environmentalists. The pesticide industry and environmentalists would at last be driving in the same direction — towards the development of new compounds that exert specific action against one insect species, and which will not contaminate the environment or threaten wildlife.

The first efforts to implement this new strategy are already evident (see the News Highlight and Feature Article in this issue). So too will it likely be apparent in discussions at the IUPAC-sponsored 5th International Congress of Pesticide Chemistry to be held next year in Japan. This conference will consider political, economic and philosophical aspects of pesticide use, and further pesticide research, for the improvement of human welfare.

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A note to IUPAC Commission members from IUPAC President Zollinger

Maintaining a sufficient income for budgetted IUPAC activities has always been a difficult procedure, aggravated by the time lag inherent in Council decisions. A high rate of inflation during recent years and particularly the paid rise in the major item — travel costs — has outrun the indicated procedure. An income plan has, however, been devised by the Finance Committee to be presented at the 1981 Leuven General Assembly.

During the interim period, IUPAC has been forced to cut costs to bring expenditures in line with income. Thus, Council instructed the Finance Committee in 1979 (at the Davos General Assembly) to suggest means to reduce the costs for the Leuven Assembly by $100 000. As is well known, the accommodation in Leuven will be — for the first time — based on the use of campus facilities, and air travel reimbursement has been adjusted to give equal chances for all delegates to cover minimum costs around the world, ensuring that no hardship is caused.

The reaction to the allowances allocated for the Leuven General Assembly has demonstrated that attendees responded very positively to the financial challenge. The Officers of IUPAC and its Finance Committee wish to express their thanks for this aid to keep costs down with maintenance of the quality of IUPAC activities.

NEWS HIGHLIGHTS

Discriminate use of pesticide is vital to future insect control strategy

The selective application of pesticides, integrated with other insect-control methods, will be essential if the effectiveness of chemical insecticides is to be maintained. Too often in the past, the indiscriminate and excessive use of pesticides has imposed strong selection pressure on insect populations, allowing only insects with the highest insecticide resistance to survive. Without competition from less tolerant members of the same species, the surviving insects were better able to reproduce and pass on their insecticide resistance to succeeding generations of the species.

If the present strategy of controlling insect pests with chemical insecticides is to remain viable, a new outlook is required by farmers, the food industry and pesticide manufacturers. At a recent meeting on Crop Protection Chemicals (held in February by the Royal Society, London), representatives of the agrochemical industry supported the view that the development of insecticide resistance was not inevitable—it could be halted or held back. Discussion at the meeting indicated a willingness to attack the problem on this front—the controlled applicaton of pesticides, rather than simply continuing to develop new insecticides to replace those which were losing effectiveness.

One factor contributing to this change in course is the growing difficulty and expense of developing new insecticides. Since pesticide researchers first sought compounds to replace DDT, they have enjoyed much success. Progressively higher potency has been achieved in each new generation of insecticides. However, at the same time, there has been a steady increase in the number of compounds that needed to be screened in order to identify active new insecticides. About 12 - 15000 compounds must now be synthesized and tested (each costing about US$1000) for each new compound developed. By 1990, if present trends continue, about 90 000 compounds might be screened for each new insecticide introduced.

Compliance with stringent government regulations also contributes to the cost of pesticide development. Dr. J. T. Braunholtz (of ICI's Plant Protection Division in the UK) estimated that field testing and safety evaluation account for about 45% of pesticide research & development costs.

Despite rising costs of introducing new pesticides, the agrochemical industry continues to spend about 7% of its income on insecticide and herbicide research and development (twice the rate of the chemical industry overall). Pesticide developers must contend with the escalating costs of petroleum-based chemicals from which pesticides are made, but this might actually provide a relative cost advantage favouring pesticide use. The amount of energy and hydrocarbons consumed in the manufacture of pesticides is dwarfed by the energy requirements of fertilizer production, plowing and harvesting. Agrochemicals represent only 2.5% of the total energy used in agriculture. Without the use of insecticides and herbicides, farmers would need to adopt alternative farm-

New pesticide applicator devices, such as ICI's Electrodyne nozzle (shown above being field tested in Nigeria) greatly reduce wasteful and environmentally damaging loss of pesticide spray into the air and soil. A high voltage at the nozzle breaks the pesticide spray into fine droplets, whose electrical charge draws them directly to the leaves of crop plants. Very little electrical power is required for operation of the nozzle, and the high voltage can be generated by a small unit in the handle of the device. Pre-mixed bottles of pesticide are inserted directly into the nozzle, reducing handling of pesticide solutions and the risk of accidental spills or worker exposure *(photographs courtesy of ICI's Advanced Technology Group).*

ing methods which require more intensive soil tillage and greater use of fuel.

Partly because of the need to minimize chemical consumption, the agrochemical industry is demonstrating fresh interest in improving procedures for the application of pesticides. Present methods are wasteful and inefficient; only about 0.02 - 0.03% of applied pesticides ever comes into contact with insect pests. Most pesticide spray does not deposit on the crop, but enters the soil or is carried into the air.

Ideally, insecticide should be applied so that it uniformly covers vulnerable areas of the protected crop. This requirement could hardly be met with organochlorine pesticides, whose application rate of 1 kilogram per hectare corresponds to a uniform layer only 0.1 microns thick covering the leaf area. Application rates of new pesticides are less by a factor of ten, making uniform distribution even more difficult.

More precise application of pesticides—only *where* and *when* they are needed—would not only reduce chemical consumption, but would minimize deleterious environmental effects of pesticides and inhibit the development of insecticide resistance. Here, as was emphasized by Prof. T.R.E. Southwood (Oxford University), the objectives of the agrochemical industry, environmentalists and the food industry all aim in the same direction. Of course, industry representatives recognize the dilemma that, by discouraging unnecessary or wasteful pesticide use, they will be giving up short-term profits. But only by moderating pesticide use, and integrating pesticides with other insect control methods, can they ensure that chemical insecticides maintain their role in crop protection.

Good crop protection can be achieved by applying very small amounts of pesticides as part of an "Integrated Pest Management" programme. Such programmes entail careful study of the life-cycle of the insect pest and crop to determine when the insect is most vulnerable. Then, pesticides and other control measures exert their effect with maximum impact and selectivity. Possible components of an integrated pest management system are the breeding of insect-tolerant crops, the release of male insects that have been sterilized (by exposure to radiation), introduction of microorganisms which infect insects, crop rotation, and preservation of natural insect predators.

Also important is the monitoring of insect populations and migrations to determine when there exists a real threat that warrants pesticide spraying. This would be far more effective than the random spraying of pesticides often practiced by farmers. Such application of pesticides is often unnecessary and might not actually maximize the economic output of a farm, but it does minimize risk. It ensures protection from insect attack at a cost of only 1 - 2% of the crop's value. The net result is that farmers tend to apply more pesticide, more often, than is needed. This heavy-handed pesticide use has the unfavourable effect of eradicating predatory insects which feed on insect pests, and establishes a reliance on pesticides for future pest control.

More effective insect control can be achieved by using a pesticide compound which provides relatively high toxicity towards insect pests and low toxicity for predatory insects. Selective toxicity may be attained through control of the dosage and timing of the pesticide. It can also be developed by the insects themselves. For example, studies of apple orchards undertaken by Michigan State University revealed that predatory mites had developed resistance to organophosphorus insecticides, while their insect victims had not. The insecticide resistance of predatory mites was successfully exploited to develop a well-balanced insect-control programme in which insect pests are destroyed by predatory insects and pesticide. In this case, as Prof. B.A. Croft noted, the same very effective control of insect pests might not be achieved with periodic massive doses of pesticide or by using a new, more toxic insecticide. This example illustrates the potential of "integrated pest management", whose advantages have become widely touted. Yet, at present, integrated pest management is practiced on a limited scale with only a few crops in a few countries.

The introduction of new insect control strategies might help guide the development of new insecticide compounds. Pesticide researchers might seek a new range of compounds offering those properties that are best suited for integrated pest management programmes. High toxicity might not be the primary goal, as pointed out by Dr. I.J. Graham-Bryce (Director of the East Malling Research Station in the UK). Certainly, the selectivity of the compound in its action against the "target" species will be extremely important. Other characteristics likely to be sought in new pesticides are low adsorption to soil particles (or high adsorption, depending upon the application), low volatility and rapid action. To be effective, insecticides might not need high toxicity—or even to kill insects at all. The goal of crop protection chemicals is not necessarily to kill insects, but to protect crops. This goal might best be accomplished by compounds that act very quickly or which influence insect behaviour.

Pesticide researchers might also turn their attention to the development of pesticide resistance, about which very little is known. No one understands which molecular features or physical properties accelerate the appearance of insecticide-resistant strains. Some insecticides have induced resistance very quickly, while others are still effective after nearly two decades of widespread use. Very few research programmes are investigating the development of insecticide resistance; nearly all are undertaken in Japan. Yet, the development of resistance—and not the introduction of new pesticides—will be the critical factor determining how long the strategy of chemical insect control can be successful.

Clues to pesticide action are gleaned from study of DDT molecule

More than any other chemical, DDT has etched a course for the chemical industry to advance in the 20th century. No other chemical has offered such dramatic short-term benefits, saved so many lives, and so effectively demonstrated the potential of chemical products to improve life and health. Yet at the same time, DDT has become one of the most pervasive and persistent environmental contaminants.

The very high toxicity of DDT to disease-carrying insects was recognized soon after the compound was discovered in 1939. With the use of DDT, malaria was eliminated in Italy in 1945, and global eradication of malaria seemed a realistic goal. In the following 25 years, malaria was virtually eliminated from 37 countries with a population of 728 million. The toll from malaria in India alone was reduced by 3/4 million deaths each year, extending life expectancy from 32 years (in 1948) to 52 years in 1970.

However, the very properties that allow DDT to be a very effective insecticide—its stability, low vapour pressure, insolubility in water, and high fat solubility—are also responsible for its accumulation in the environment. DDT and its breakdown products are found everywhere on Earth. Much of the estimated 100 000 tons of DDT used during the last three decades remains in the soil, plants and bodies of animals and man. Indians are reported to have 16 ppm DDT in their body fat, and an additional 10 ppm DDE (a metabolic breakdown product of DDT). Eskimos have 0.8 ppm DDT and 2.2 ppm DDE.

Because of the use of DDT and other chlorinated hydrocarbons, a number of animals species face extinction. Insecticide residues are already implicated in the recent extinction of some bird species, apparently caused by a reduced egg shell thickness and decreased ability to produce offspring. Among a colony of brown pelicans in California (USA), for example, most eggs were found to have shells so thin that they collapsed before the chick could hatch. These eggs had an average DDE concentation of 75 ppm, with the thickness of each shell varying inversely with its content of DDE. At the same time as insect control programmes have increasingly threatened the survival of wildlife, many insects have been developing a resistance to DDT (utilizing an enzyme to decompose the DDT molecule into less toxic products).

The insecticidal activity of DDT against a broad range of insect species was thought to be well understood by its developer, Paul Muller. He was familiar with the mothproofing agent methyl (p-chlorophenyl) sulfonamide, and knew that di (p-chlorophenyl) sulfone was a potent stomach poison. Perhaps, it was thought, this high toxicity could be retained in a di (p-chlorophenyl) methyl "toxaphore" group, linked with a $-CCl_3$ "conductophore" group to direct this toxicity to the central nervous system of the insect. The $-CCl_3$ group would enhance the fat solubility of the compound, as was necessary for it to cross the nerve cell membrane. $-CCl_3$ must have appeared to be an obvious "conductophore" group for the nervous system, as $H-CCl_3$ (chloroform) was a well-known anaesthetic agent. The predicted behaviour of the compound, DDT (2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane), was borne out, and Muller received the Nobel Prize in 1948.

Subsequent studies showed that, while Muller's conclusion was certainly correct, the underlying reasoning which led him to consider DDT was wrong. Compounds with a similar structure were later synthesized that were also potent insect nerve poisons, but in which chlorine atoms of the CCl_3 group were replaced by methyl, nitro or fluorine atom groups. This also showed that the CCl_3 group was not acting as a "toxophore"—presumably by releasing HCl within the nerve cell of the insect.

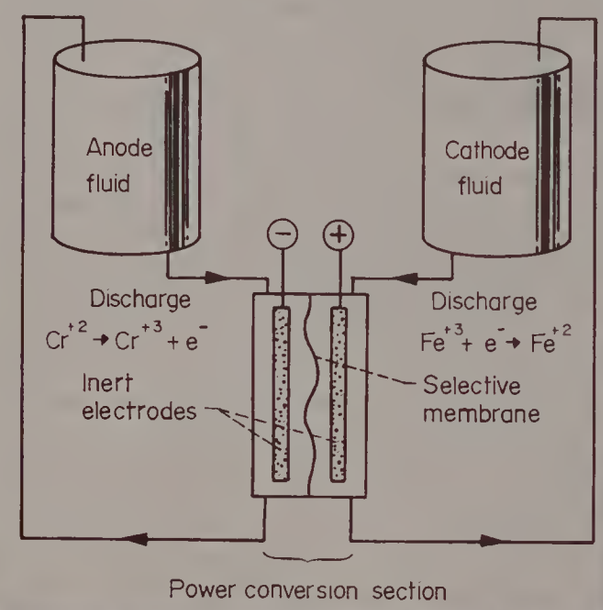
During the 1950's, many theories were advanced to explain DDT's activity, as Colin Kennard and Graham Smith explain in the article *Mode of Action Theories for DDT-type Insecticides* (published in *Chemistry in Australia,* October 1980). These theories discounted the simplistic concept of a "toxophore" group within the molecule. They incorporated the developing notion that different parts of the molecule interact with one another to form a chemical structure with the correct size, shape and charge distribution to stimulate a receptor in the insect nerve cell. One group proposed that the CCl_3 group interacted with the p-chlorophenyl group, preventing its rotation. If this were true, an even more potent insecticide could be synthesized by locating chlorine atoms on the ortho position of the benzene rings, effectively blocking their rotation. However, when the o-chlorophenyl isomer was made, it was found to have no insecticidal activity. Insecticidal activity was also much reduced in a DDT-like compound containing the p-chlorophenyl groups locked into position by a CH_2 bridge.

Researchers are still synthesing DDT analogues, and trying to determine which structural features contribute to insecticidal activity. No theory has yet adequately explained how DDT acts, or why its structure endows such high toxicity. Molecular detectives have found only one substantial clue: the most critical feature of the DDT molecule and its analogues appears to be the dihedral angle between the planes of the two benzene rings. Among a series of DDT-like compounds, the lethal dose varies in a consistent way with the dihedral angle of each compound. The relationship, which can be expressed in a mathematical formula, indicates that a dihedral angle of 116° is optimal for insect toxicity. DDT has a dihedral angle of 115°. The more the dihedral angle deviates from 115°, the less is its insecticidal activity: a compound whose dihedral angle deviates from the optimal value by 6° has only one-tenth the insecticidal activity.

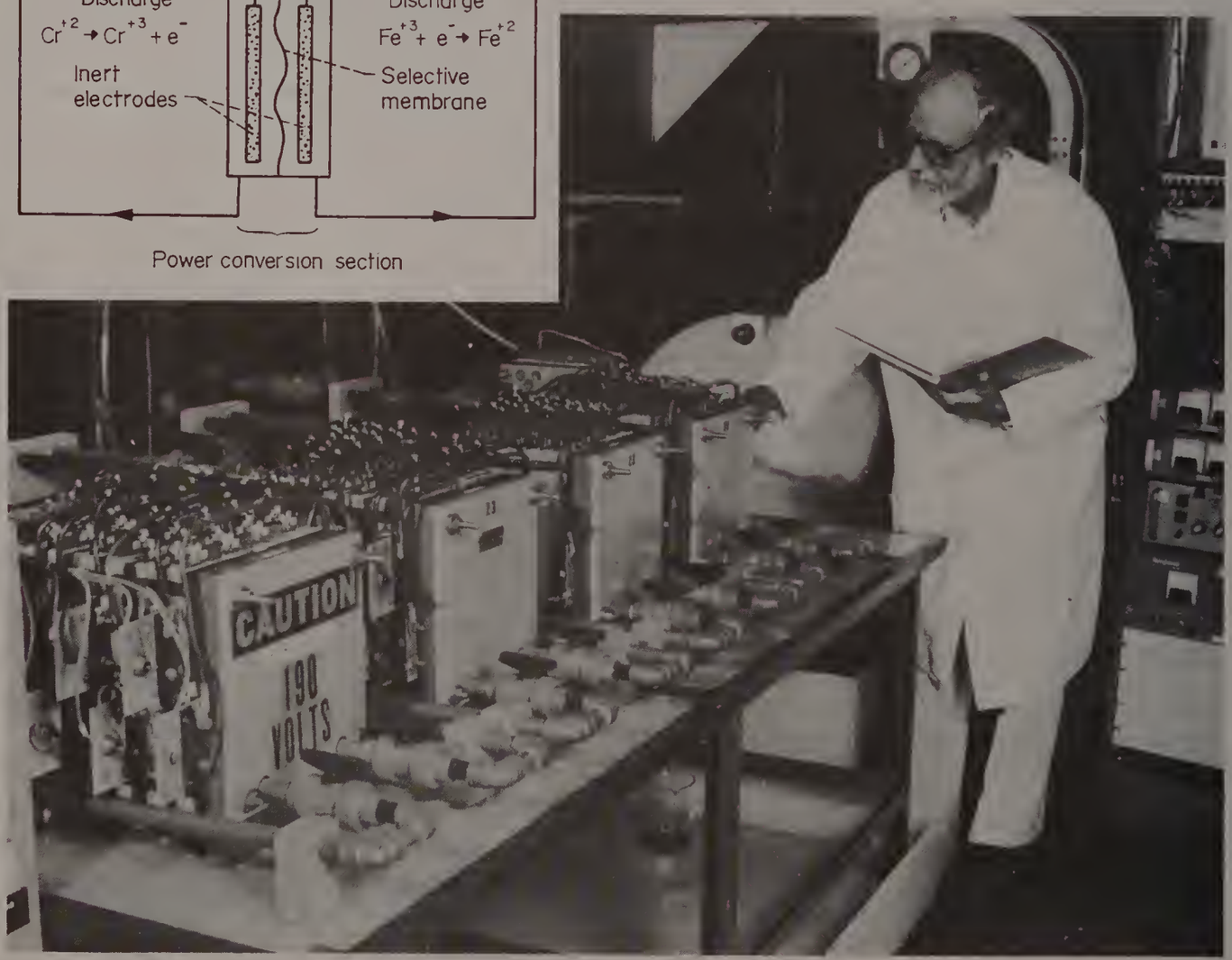
Chemical energy storage provides link for use of solar electric power

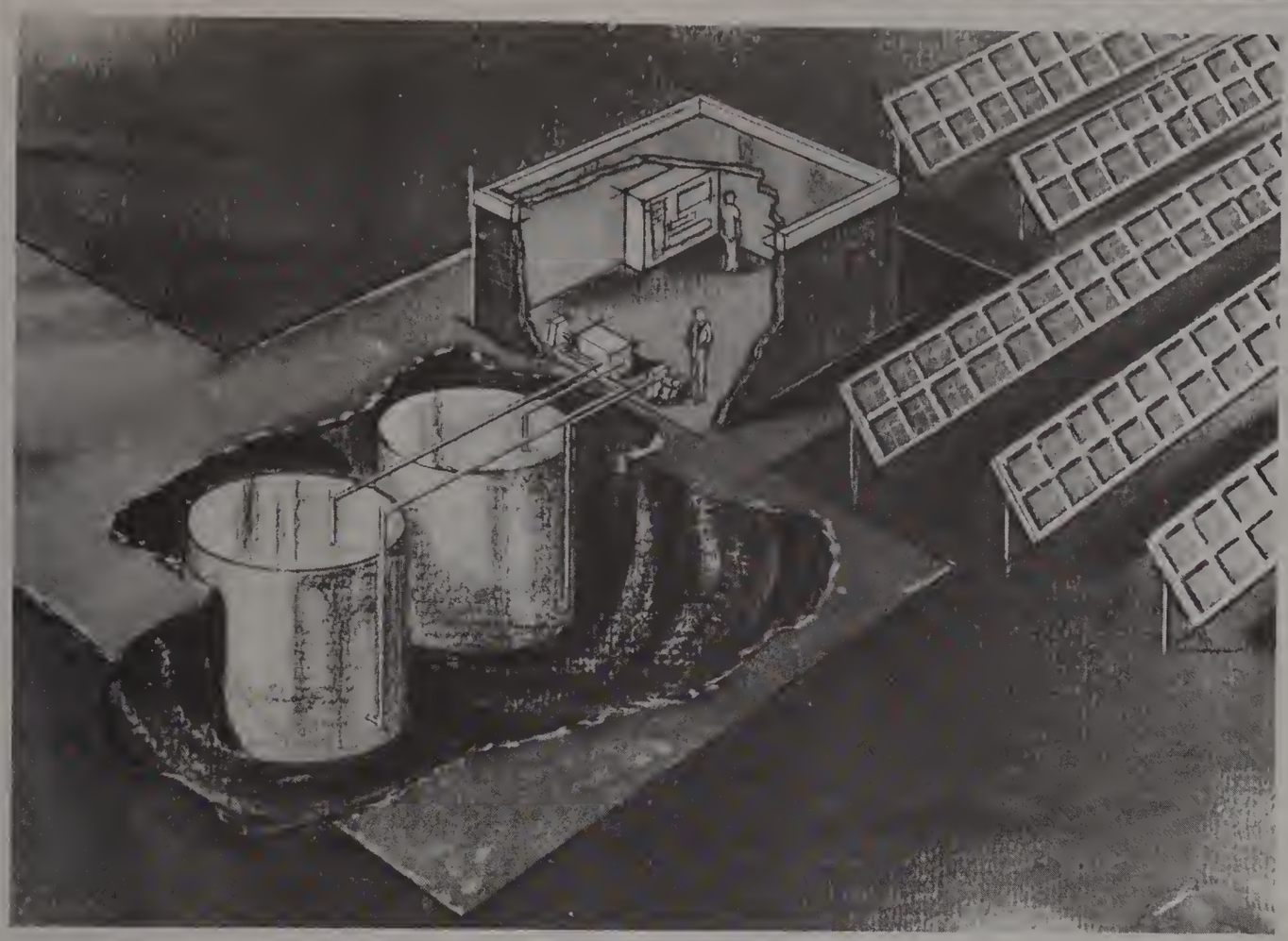
A major obstacle to the utilization of solar or wind power in villages and remote installations has been the lack of an inexpensive and compact energy storage system. Sunlight and wind are not always available when electrical energy is needed. What is needed is a system to store the energy collected during sunny (or windy) periods, and release it at other times. Conventional lead - acid batteries can easily provide the modest power requirements of village-size communities (5 - 25 kilowatts), but very large batteries are required to provide the large energy storage capacity for 30 - 60 hours of continuous power output. Such conventional battery systems are very expensive (about US$150 per kilowatt-hour of storage capacity), and have a limited operating lifetime.

To meet the requirements for an inexpensive, low-power/high capacity energy storage system using relatively simple technology, the NASA Lewis Research Center undertook development of a Redox cell utilizing flowing oxidizer and reductant solutions. The program was carried out for the US Department of Energy. After proving the basic concept, electrochemists at NASA incorporated major improvements during testing and scale-up of the system. They have now built a small modular system, able to deliver up to two kilowatts of electrical power (about the typical requirements of a few homes). This has been integrated with an array of solar cells at the photovoltaic test facility at Lewis Research Center (in Cleveland, Ohio, USA).



An electrochemical cell, powered by flowing oxidizer and reductant solutions, forms the heart of a compact energy storage system being developed for remote installations and villages. The power conversion units shown below can deliver up to two kilowatts of electrical power, and "recharge" the oxidant and reductant solutions when surplus solar electrical power is available. This system, which was completed last summer, has been integrated with a solar cell array.





Development is now underway on a prototype system able to store 500 kilowatt-hours of electrical energy. Surplus electrical energy (from solar panels) is utilized to increase the electrochemical potential difference of oxidizer and reductant solutions, stored in two underground tanks. When power is needed, the solutions are again pumped through the power conversion unit, providing 10 kilowatts electrical power continuously for up to 50 hours. Such a system, shown here in a conceptual drawing, is expected to cost about 2/3 as much as a conventional rechargeable battery system and will have a much longer operational lifetime.

The NASA energy storage system differs markedly from conventional batteries in that the electrochemical reactants are not stored in the cell, but are contained in separate storage tanks. The reactants are entirely in solution. The electrodes serve only as current collectors and reaction sites. Two reactant solutions (one containing oxidizing agent, the other a reductant) are pumped through the cell to generate electrical power. When surplus power is available, the solutions are once again pumped through the cell, and restored to their initial chemical composition. Energy storage capacity of the system can be increased by simply expanding the storage volume for the two reactant solutions. A very compact "power conversion cell" can utilize the electrochemical energy contained in a very large volume of solution. A ten-kilowatt cell stack, designed for use in village-scale systems, would occupy a space of only 0.6 m^3, but could generate 200 kilowatt-hours of chemical energy from about 44 m^3 of oxidizer and reductant solutions.

The NASA Redox cell generates power by utilizing the different oxidation potentials of two reactant solutions. The "anode fluid" contains chromium chloride, with chromium ions in the reduced Cr^{+2} form, while the "cathode fluid" contains iron chloride, with the oxidized Fe^{+3} ion. The two solutions flow simultaneously into their respective anode and cathode compartments, which are separated by an ion exchange membrane. This membrane is the key to the successful operation of the cell. It provides a selective barrier to chromium and iron ions, preventing cross-contamination of the two reactant solutions. But the membrane allows chloride ions to diffuse from the cathode compartment to the anode compartment as power is generated (and in the opposite direction during recharging of the reactant solutions). This ion flow balances the electron current driven through the electric circuit by the voltage (electromotive force) developed by the cell.

As reactant solutions flow through the cell, electrons are donated to the cathode by Cr^{+2} ions which, in this way, are oxidized to Cr^{+3}. At the opposite electrode, Fe^{+3} ions accept an electron, and are reduced to Fe^{+2}.

Depending upon the concentrations of oxidized and reduced ions in the reactant feed solutions, each cell generates 0.9 - 1.2 volts. The electron current flows through a series of cells, arranged in a stack, each cell contributing to the total electromotive force developed by the battery module. The flow of reactant solutions to each cell is controlled so that the entire

Village-scale power generation is key to rural development & industrialization

Escalating costs of hydrocarbon supplies will present a serious threat to the industrialization and improvement of living conditions in developing countries. Here, the need to develop non-conventional energy sources is acute. These countries have little prospect for importing petroleum-derived fuels or chemicals. Energy needs are—and must continue to be—provided by local resources. Improvement in the standard of living depends upon utilizing and upgrading resources in new ways to provide for local needs.

Only recently have trained scientists sought to identify energy resources and needs of rural Third World populations that could be met with modern technological methods. These studies point toward the construction of village-scale energy centres to convert locally-produced agricultural wastes into fuel, and to provide surplus energy and byproducts for new local industries.

One of these studies, *The Design of Rural Energy Centres**, investigated the lifestyle of the people in a typical Indian village, and how modern technology could be adapted to meet the villager's energy requirements. The study was carried out in Pura, which is representative of the half-million villages in India containing 85% of the Indian population. The investigators discovered that the major fuel requirement of the village was for cooking. Heat energy for cooking is generally obtained by burning firewood, which is gathered from surrounding shrublands. Collecting firewood diverts a great deal of time and effort from productive enterprises. An average 2.6 hours/day are spent by a member of each family to collect about 10 kg of firewood required for cooking.

Firewood presently provides 97% of the fuel requirement of Pura, which is believed to be a typical village. Providing alternative sources of heat energy for cooking, note the authors of the report (Amulya Kumar N. Reddy and D.K. Subramanian, of the Indian Institute of Science), should thus be the first priority for rural energy planning in India. Yet, the need for cooking fuel—the energy shortfall of paramount importance in many developing countries—is often totally ignored by urban-based development planners.

One potential source of cooking fuel is biogas, a methane - carbon dioxide mixture made by fermentation of cattle dung. During anaerobic digestion, bacteria convert hydrocarbons in the waste to methane. Proteins are broken down, liberating nitrogen as ammonia and other nitrogen compounds which are readily utilized by plants. The residual slurry contains all the nutrients but little of the odour of the raw feed material, and is an excellent fertilizer. Thus, biogas generation offers an integrated system of energy production, nutrient recycling and waste treatment.

The potential benefits of biogas production have been apparent for some time (see feature article in *Chemistry International,* 1979, No. 3), and in fact, thousands of family-size biogas plants are reported to be operating in India, the Szechuan province of China and Republic of Korea. But economics of scale and maximum utilization of energy and byproducts can only be fully exploited by village-scale biogas plants. In their study of Pura, Drs. Reddy and Subramanian estimated that a community-size plant providing the entire cooking energy needs of all villagers (56 families) would cost only about six times as much as one family-size unit. A centralized biogas system, utilizing manure from all cattle in the village, would provide cooking gas to each family (including those without cattle) and produce surplus gas for industrial power needs. In this village, surplus gas might drive a 5 horsepower (3.7 kW) engine to pump water and supply electric power for evening lighting. It would also power a ball mill for grinding rice husk ash and lime to make cement. Revenues from cement and electricity production are projected to pay back the entire cost of the biogas plant, gas distribution system, biogas engine and generator, and ball mill (equivalent to a present cost of about US$10 000) in less than 5 years. Depending upon local resources and conditions, other industrial projects could be undertaken on a village level, using mechanical power, methane, electricity or low-grade heat provided by the energy centre.

A rural energy system for the Third World need not only be technologically workable, but must be compatible with the lifestyle, social requirements and economic needs of the people it is intended to serve. An energy centre for one village can be a useful prototype—to be modified and adapted for use elsewhere; it cannot be standardized for application in other countries, societies and cultures. Furthermore, a rural energy centre must be phased-in gradually. Each technological innovation disrupts the social and economic system, which requires a period of time to reach a new state of equilibrium. The finite "relaxation time" of the village system demands that new innovations be introduced only after previous changes have been assimilated. Too often in the past, new technology has been imposed as a massive perturbation which throws the village system into instability, from which it can only recover by rejecting the externally-imposed technology.

**The Design of Rural Energy Centres, by Amulya Kumar N. Reddy and D. K. Subramanian. Proceedings of the Indian Academy of Sciences, Vol. C2, Pte 3, pp. 395 - 416. Condensed and reprinted in "Abstracts of Selected Solar Energy Technology", Vol. 2, No. 9 (October 1980).*

module produces a constant 120 volts.

After passage through the cell, the two solutions have become largely depleted of their initial concentration of Cr^{+2} and Fe^{+3} ions, and now contain mostly Cr^{+3} and Fe^{+2}. These solutions are stored outside the cell, to be regenerated when surplus electrical power is available.

Since the feasibility of Redox flow systems was first reported seven years ago, major advances have been made in membrane and electrode technology. These are described by Margaret Reid and Lawrence Thaller in the report *Improvement & Scale-up of the NASA Redox Storage System* (NASA Report TM-81632, August 1980). They report that the selectivity and chloride ion conductivity of the ion-exchange membrane have been greatly improved. A new procedure to impregnate one electrode with catalyst has accelerated the chromium ion oxidation/reduction reaction. Because of modifications in materials and cell construction, power levels that the cell could deliver were dramatically improved. Hydrogen evolution during cell recharging, which creates an imbalance in the relative concentrations of Fe^{+3} and Cr^{+2}, was also greatly reduced by improved electrodes. Novel features have been incorporated into the Redox system to deal with any imbalance of ion concentrations which arise during repeated charge/discharge cycles, and to maintain a constant output voltage under a wide range of conditions.

Although further technological improvements will provide additional performance and cost benefits, the membranes and electrodes now available will provide adequate power output and stable operation for solar energy storage. The main remaining step is further scale-up in the design, construction and testing of complete systems of 10 - 500 kilowatt-hour storage capacity. A self-contained village-size solar energy storage unit should cost about US$365 per kilowatt power output and an additional $90 for each kilowatt-hour storage capacity (based on recent manufacturer's selling price estimates, assuming production of 1000 units per year). Unlike conventional lead-acid batteries, whose storage capacity deteriorates after several hundred charge/discharge cycles, no deterioration in the Redox flow system is apparent after 20 000 deep discharge cycles (equivalent to more than 50 years operation).

Current plans call for development and testing of a 10 kilowatt/80 kilowatt-hour prototype system. After initial testing of the prototype (to be completed by December 1983), operation of the system for solar energy storage will be proven in field tests. Following that, it is expected that commercial units will be manufactured by industry.

Low mobility of research staff elicits call for corrective measures

Deterioration in the quality of university research is highly probable, predicts a report by the European Science Foundation (prepared for the Commission of the European Communities), unless measures are taken to reverse the present stagnation in recruitment of new personnel and declining mobility of academic staff.

Since 1975, the report notes, very few new posts have been created at universities, and recruitment of university teachers and researchers has almost come to a standstill in most European countries. The problem stems from the rapid expansion in student numbers in the 1960's accompanied by a substantial increase in the number of established posts for teaching and research personnel in universities and research institutions. The effects of a diminished birth rate and reduced economic growth were felt at the same time as the output of well-qualified graduates peaked. University expansion slowed in the early 1970's, and came to an end in most industrialized countries by the mid 1970's.

Staff recruited during the 1950's and 1960's, which comprise a very high proportion of present faculty in European universities, have a median age of 40 - 45 years and may be expected to remain in their posts for another 20 - 25 years. Very few university staff members are presently retiring or moving to new positions. The proportion of new staff members appointed each year is extremely low. In 1978 -1979, the annual replacement rate in the German Republic was 1.5%, compared with the average employment rate of 15% in years prior to 1972. This situation is reported to be particularly serious in mathematics, physics and chemistry.

The problem is by no means limited to

Europe, but appears to be ubiquitous in all Western countries. Indeed, Dr. K. Jankowski reported (in the February 1981 issue of *Chemistry in Canada,* page 6) that the average age of full professors in Canadian universities has been creeping upwards during the last ten years—from an average age of 42 years in 1970, to 45 years in 1975, to 48 years in 1979 - 80. He projects that the end of the 1980's will be characterized by a saturation of higher professorial ranks, followed by a mass departure and retirement of university staff.

The European Science Foundation report predicts that the distorted age distribution of university staff will not disappear within the next 20 years. It envisages that present conditions will be maintained, or become worse: job openings due to retirement will be few; few new posts will be created. The influx of new research staff will likely be inadequate to balance the aging of present academic staff. Introduction of new personnel and fresh ideas into the system, considered to be an integral part of research, will be virtually halted. The report states that this "aging of tenured staff and present shortage of (new) positions represent a threat to the future health and vitality of science".

Accentuating the standstill in recruitment of new research staff is the virtual immobilization of present faculty in their posts. Contact between scientists from different backgrounds and institutions could partially offset the stagnation in recruitment of new talent. By undertaking short study visits to learn new techniques or year-long research fellowships in another institution or country, the individual scientist acquires a broader perspective of his own field of expertise. However, the mobility of university researchers seems to be inadequate (with virtually no exchange of scientific staff between universities and industry), and in fact, the report indicates that such mobility has actually declined in recent years. "Academic inbreeding" appears to be on the increase; the few vacancies which do arise being filled from within university departments. Furthermore, the inclination of staff members to undertake study visits or do research in other laboratories can be expected to diminish as they grow older.

The decreasing mobility of academic staff is most severe among young scientists who could benefit most from travel and research abroad. Many young researchers who have no permanent position prefer to stay in their home country in order not to lose their place on a waiting list. Individuals who go abroad without having first secured a tenured position often encounter difficulties in finding employment on their return.

Experience abroad has previously been regarded favourably in consideration for promotion, but many scientists feel that this is no longer the case. Some senior scientists are unwilling to take a temporary post outside their own country because they are concerned that their prospects for promotion might suffer as a result.

All researchers who undertake temporary posts in other countries face various bureaucratic, financial and cultural obstacles, and they often receive little guidance or support from the institutions or governments involved. Different countries may have incompatible requirements for pension schemes, social security, health or accident insurance and taxation. In some cases, scientists must comply with complicated procedures to obtain work permits, and difficulties are frequently encountered in obtaining a work permit or employment for the researcher's spouse. Education of the researcher's children can also pose problems with moving to/from another country. Researchers who wish to travel often find that information about grants and post vacancies is not readily available or is poorly organized.

The report *Employment prospects and mobility of scientists in Europe** reviews the measures being undertaken to improve the present situation. A long-term goal advocated by the report is for universities to strive for a steady intake of young researchers. It recommends that sufficient permanent posts be created to increase the annual appointment of new staff by one percent of the present number of faculty (a 3% replacement is necessary to restore a long-term equilibrium of hiring and retirement). This would lead to a continuous flow of new talent into teaching and research, and avoid an acute shortage of trained personnel in the 1990's, when retirement rates begin to rise and job opportunities improve.

The report points to several schemes of advanced study institutes, fellowship programmes, and collaborative research projects which have been proposed or introduced. A discernable effect could be achieved on a European scale, the report estimates, with an investment of about US$7 million—with the majority of funds allocated to research grants to encourage collaborative projects. In the United Kingdom, a series of Collaborative Awards in Science & Engineering have been established to support postgraduate students working on research projects organized jointly by university departments and industry laboratories. The cost of this programme (now extending to approximately 1800 students) is borne primarily by the Science Research Council (about US$8000/student), with industrial laboratories contributing at least US$700 towards each project.

Most existing and proposed schemes will operate on a limited scale. In the present economic climate, it is uncertain how much of this support can be expanded. There are, however, several steps that can be taken at very little cost to increase the mobility and exchange of university faculty. Among the steps sug-

gested by the ESF report are that more universities and research institutes establish reception centres to help foreign academics solve social and administrative problems. It urges that salaries of visiting research fellows be related to salary levels of colleagues in the host institution and the cost of living in the host country, with financial aid to cover travel costs and additional expenses involved in an international move.

Finally, the report suggests that postgraduate research training be reappraised, taking into account the present difficult job situation. While the report acknowledges that training in basic research requires a degree of specialization, the author recommends that post graduate training provide a broad base of skills that will enable students to diversify into allied fields, and that educational assistance be provided for those who wish to do so.

**The report, Employment prospects and mobility of scientists in Europe, (October 1980) presents its findings and recommendations in two parts: one deals with conditions generally prevailing in the European Community; the second examines specific situations in each country. Its preparation was carried out by Dr. J.P. Kreyenberg, and overseen by a Steering Committee chaired by IUPAC Secretary General Ourisson. The report is available from the Commission of the European Communities, DGXII, Division B-2, Brussels, Belgium.*

Resolving the dilemma about carcinogens and cancer

> *". . . it is simply not possible with all the animals in the world to go through new chemicals in the blind way that we have at the present time, and reach credible conclusions about the hazards to human health. We are at an impasse. It is one that has deep scientific roots, and we had better do something about it."*
>
> *Joshua Lederberg, geneticist*

Concern about the dangers of long-term exposure to chemicals has greatly increased in the last decade, posing an immense challenge for toxicologists. In the past, toxicologists were involved almost entirely with short-term effects and acute illness caused by chemical poisons. As evidence accumulated that some chemicals could cause cancer, chromosome damage and birth defects, the focus of toxicology gradually shifted onto the effects of prolonged exposure to chemicals at very low concentrations.

Largely because of concern with carcinogenic compounds, the mandate of government regulatory agencies to protect workers and the public has been extended. So too has the role of the toxicologist. However, the study of chemically-induced cancer posed formidable difficulties never encountered with acute toxicity studies. After years of study, toxicologists have yet to identify all carcinogenic, mutagenic and teratogenic compounds to which workers and the public are exposed. Among those compounds that *are* known or suspected of being hazardous, toxicologists are unable to agree on exposure levels that can safely be tolerated.

In the past, safe human exposure levels have generally been derived from the immediate response of a group of animals subjected to the test compound. Several animal species were tested, and the one most sensitive to the test compound was selected. Then, the toxicologist noted the maximum concentration at which the chemical caused no observable effect on the group of animals. This concentration is reduced by a safety factor of 100 to establish maximum levels for human exposure. So, for example, if 100 ppm of a food additive produced no adverse effects in mice (or in other test animals), then 1ppm would be accepted as a safe level in the human diet. The safety factor of 100 is a crude hedge, compensating for a total lack of knowledge about whether humans might be more susceptible than the animals tested, and allows for the variation in susceptibility from one individual to another. This relatively simple procedure has been used by government regulatory agencies to set exposure levels for food additives and pesticides. It has

worked well over the years. No known cases of food poisoning or acute pesticide reactions have been caused by exposure to chemicals at these levels.

A similar general safety factor might, or might not, be applicable to carcinogenic compounds. The difficulty lies in establishing the level at which a carcinogen exhibits no observable effect—if such a level exists. After exposure to a carcinogen, no immediate effect may be apparent. Years may pass before a cancer develops, and then, it is difficult to prove that exposure to this chemical had actually caused the cancer. Even a potent carcinogen, at low concentrations, might induce cancerous tumours in only 5% of the test animals. At lower concentrations, cancerous tumours appearing in a few test animals might not be distinguishable from tumours that would have appeared spontaneously if the animals had never been exposed to the test compound.

The most reliable method of evaluating the long-term effects of any chemical is to expose a large number of animals (usually two species) to the test compound over an extended period of time. Each test might employ as many as 500 - 600 rodents, and last two years. Depending upon how the animals are exposed to the test compound (through oral ingestion or inhalation), such tests usually cost US$400 - 750,000.

The animals are exposed to the test compound at concentrations higher than those actually encountered in the human environment. It is tempting to subject the test animals to overwhelmingly large doses of the compound in order to obtain definite results more quickly, but this undermines the validity of the test results for evaluating the chemical's long-term toxicity. As Dr. Henry Sherman points out in his article *Toxicology, A Discipline under Attack* (published in *Chemistry in Australia,* November 1980), the acute effect of exposure to a large dose does not necessarily have a direct bearing on its long-term toxicity. Dr. Sherman points to recent evidence that high concentrations of a chemical are metabolized and detoxified differently than the same chemical at low concentrations. Above a threshold concentration, Dr. Sherman explains, the compound overloads the natural detoxification mechanism or DNA-repair mechanism of the organism. He cautions that an animal's response to a massive dose is of dubious value for predicting the effects of low-level long-term exposure.

A number of laboratory tests have been developed which can rapidly screen chemicals for carcinogenic potential. Most widely used is the Ames test. It detects mutations that are induced in bacteria, and in this way, implicates chemicals that have potential ability to cause cancer. A negative result does not provide absolute proof that a new compound is not carcinogenic. Nor can it show that the test compound does not promote cancer in individuals who are genetically cancer-prone. Nonetheless, a negative Ames test might allow researchers to defer extensive animal testing until they can determine if the compound has potential commercial value. A positive result shows that the compound reacts with DNA, is likely to be carcinogenic, and indicates that the compound warrants further testing. The results of an Ames test, by themselves, should not be accepted as rigorous proof of a compound's safety or carcinogenic hazard. Yet, some researchers terminate all development of a compound if it gives a positive result.

Many compounds that are indicated to be carcinogenic may already be in wide use. Very likely, it will prove impossible to prohibit entirely the use of all compounds demonstrated to be carcinogenic. Toxicologists must decide a safe level of exposure for these compounds. Some believe that there is no safe dose; that even one molecule of a carcinogen could conceivably react with DNA, produce a mutation, and ultimately cause a cancer to develop. Others belive that there exists a threshold concentration, below which the compound is not a carcinogen or has substantially less carcinogenic potency.

The concentrations of carcinogenic compounds used in animal studies would pose an unacceptably high risk to humans. In principle, it should be possible to extrapolate data from animal tests to evaluate the risk at lower concentrations: concentrations similar to those at which humans may be exposed. However, the relationship between carcinogen concentration and the resulting incidence of cancer is poorly understood, and the subject of intense controversy. Depending upon which theory one chooses, the number of cancers predicted in a human population can vary a million-fold.

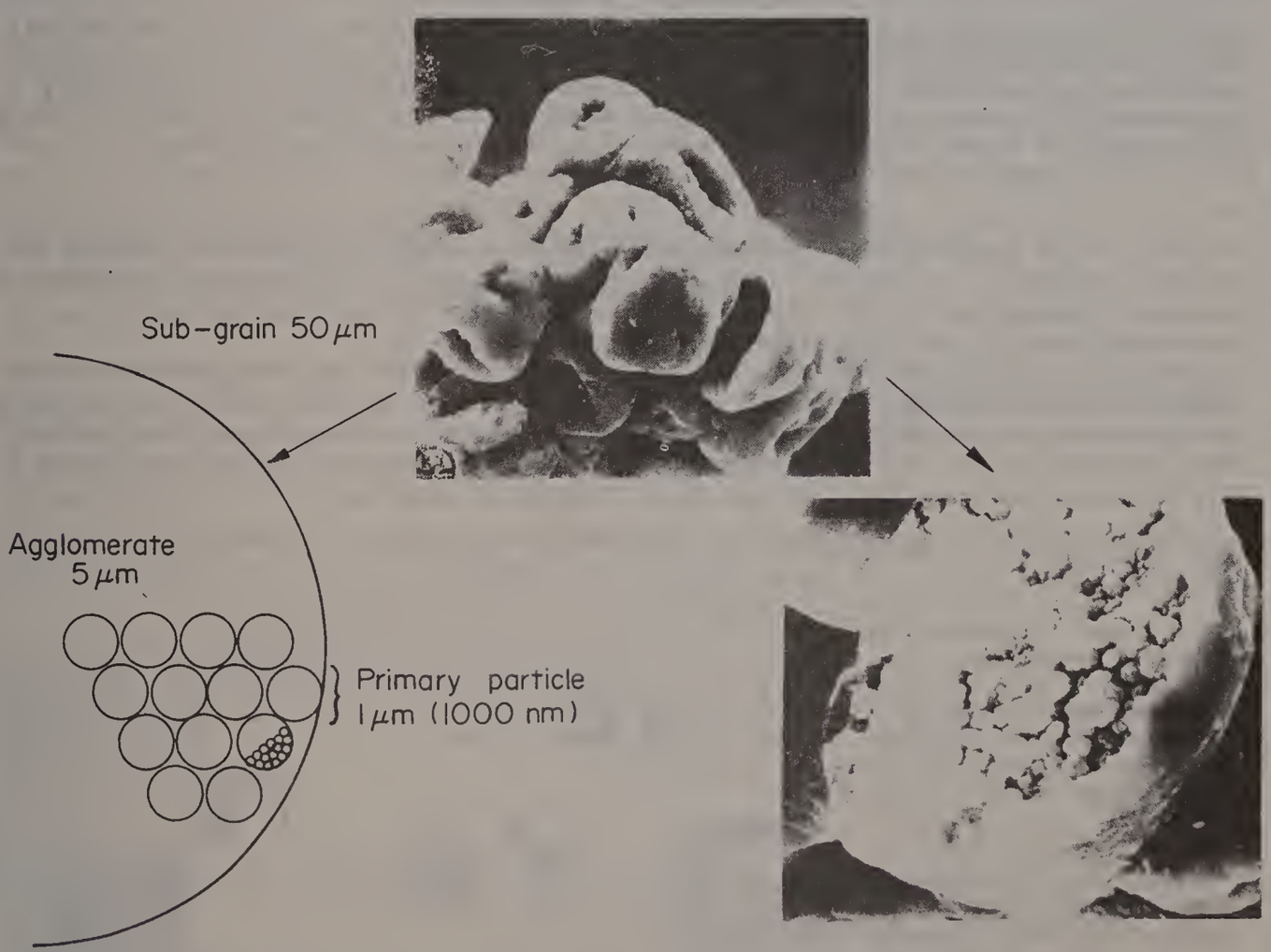
The uncertain dose : response relationship for carcinogens poses a major problem for the toxicologist. It creates an impossible dilemma for government regulators. What toxicologists *do* agree is that, as the dose of a carcinogen is reduced, the proportion of animals developing tumours is reduced. Perhaps more significant, as the dose is lowered, the time period required for cancer to develop is extended. For some carcinogens studied, a reduction in the dose by 1000-fold extends the latency period by a factor of 10. This effect (first reported by the Russian toxicologist L.M. Shaba) may be the important clue, that will permit toxicologists to assign realistic exposure levels for carcinogens. Dr. Sherman believes that it might allow toxicologists to bypass present deadlocked efforts to establish threshold concentrations (if these exist) at which no cancers would be induced. The acceptable dose for a carcinogen in the working place or environment might be one at which the latency period for cancer to develop is 120 - 150 years. At this level, a chemical would not induce cancer within the lifetime of any individual.

Polymer chemists collaborate to probe complex processes during polymerization

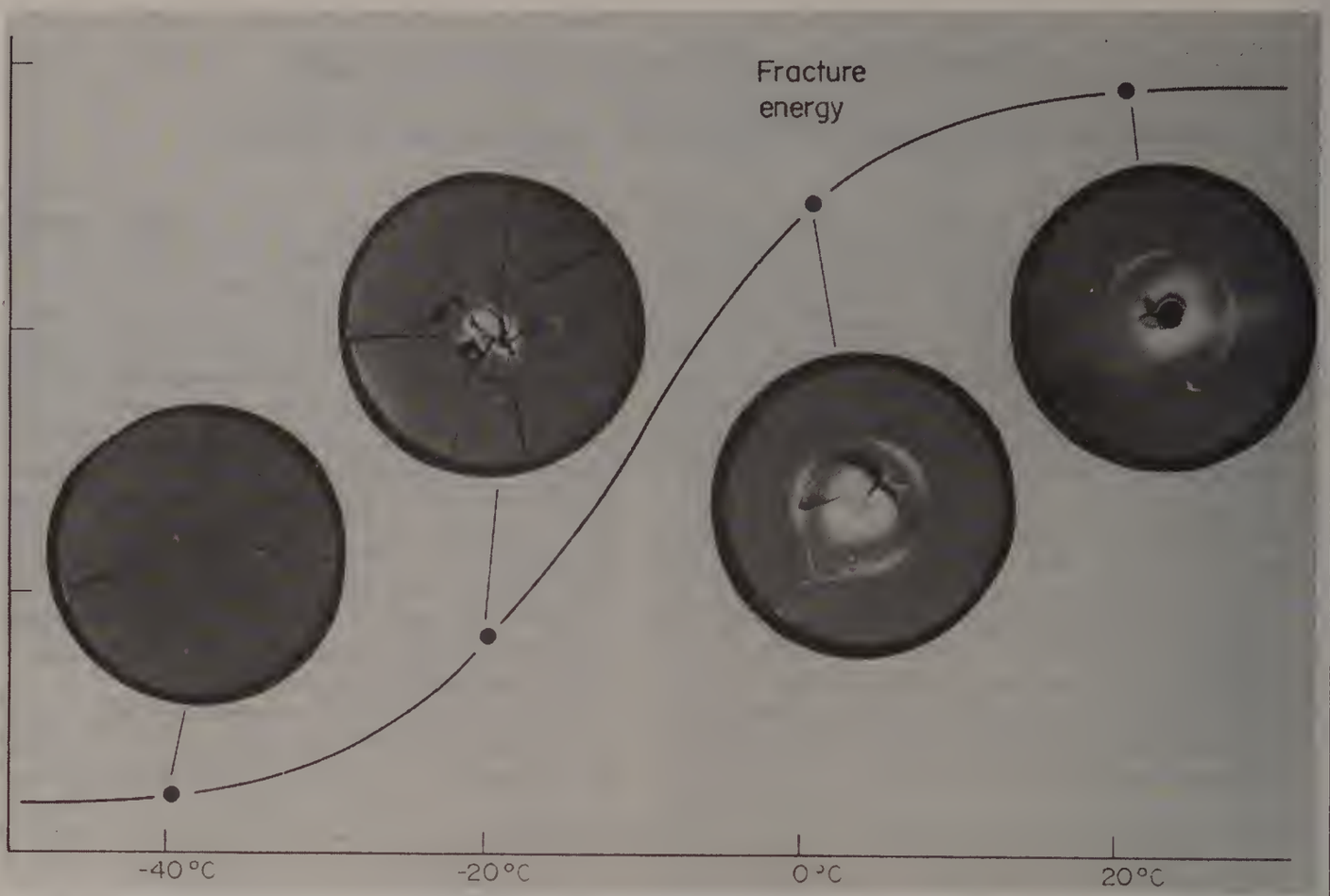
Most chemists view polymerization as a simple chemical process whereby monomer molecules react to form a polymer chain. They feel that—once polymerization is underway—the course of the reaction is clearly defined, the properties of the product are pre-determined, and the interesting chemistry is over. However, as polymer chemists have come to realize, the properties of plastic products are largely determined by events occurring at later stages of the polymerization reaction. Indeed, the wide range of properties available with commercial plastics is not achieved by simply altering the chemical structure and configuration of the polymer chain.

If polyvinyl chloride (PVC) is compared with polyethylene, one finds enormous differences in physical properties which cannot be attributed directly to the chemical structure of their polymer chains. For example, molten PVC has three times the viscosity of polyethylene with the same average molecular weight. This effect is not well understood, but it has become abundantly clear in the last decades that the flow of PVC is strongly influenced by the microscopic physical structure of the polymer—and not simple molecular interactions. Up to the late 1960's, PVC melts were thought to be homogeneous. Analysis of the flow properties of PVC then disclosed that the mechanism of flow underwent a transition at about 200°C. At low temperature, the viscosity actually increased as the polymerization temperature was increased—in direct contradiction to predicted behaviour.

To account for new experimental results reported in 1967 - 1969, the flow of PVC had to be explained in terms of its supermolecular



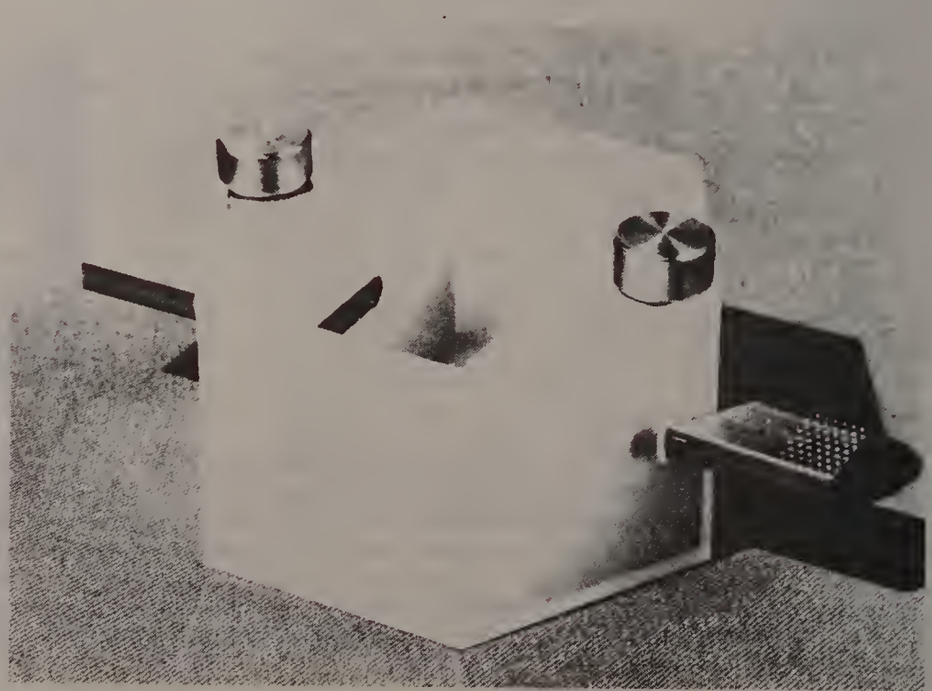
Polyvinyl chloride has a complex supermolecular structure, which strongly influences its flow behaviour and physical properties. The so-called "primary particles", about one micron diameter, are clustered together into agglomerates and subgrains. The structure of a subgrain is shown with unusual clarity in the electron micrograph on right (reproduced from *The Morphology, Rheology and Processing Properties of Polyvinyl Chloride* by courtesy of CL. Sieglaff), and is depicted graphically in the accompanying model of the subgrain structure. The upper electron micrograph, showing a group of subgrains, and the model of subgrain structure are reproduced with permission from *The Development and Importance of Suspension PVC Morphology* by Michael Allsopp.



When a projectile strikes a plastic part, the material deforms evenly—with increasing force applied to the part—until it fractures. At lower temperatures, far less impact energy is required to reach the ductile - brittle transition at which fracture occurs, as is demonstrated in this graph of "break energy" vs temperature for injection-moulded polypropylene discs. The pattern of impact damage also varies with temperature. A very different fracture pattern is evident in the polypropylene discs at -40°, -20° 0° and +20° *(diagram adapted from material provided by Dr. S. Turner, Plastics Division, ICI).*

structure, whose complexity was becoming increasingly apparent. As polymer chemistry researchers probed the polymer structure with electron microscopes, they realized that a series of interconnected aggregation steps accompanied the polymerization reaction. Vinyl chloride monomer evidently reacted to form coiled polymer chains, which aggregated to submicron-sized particles. These, in turn, flocculated to produce the nucleii of "primary particles". The process of coalescence, growth and collapse of PVC particles also occurs on the macroscopic scale.

By the time the polymerization reaction is 30% complete, the polymer has formed into strong, stable membranes, enclosing globules of reacting monomer. Further production of polymer is accompanied by a significant in-



The impact strength of plastic mouldings was evaluated by polymer laboratories participating in a collaborative study undertaken by an IUPAC Working Party. They noted in their report, *A study of impact strength testing and its relevance to real mouldings,* **that impact strength is not a single, inherent property, but rather, a combination of several properties. Here, hexagonal plastic boxes are subjected to tensile forces applied through a specially-designed clamp system** *(photograph reproduced from Working Party report).*

crease in density. The globule shrinks, and as remaining monomer dissolves in the polymer phase, it collapses. The skin of the particle folds and ruptures, causing the wrinkled appearance so commonly seen in electron micrographs.

The physical structure of PVC, more than in any other polymer, is crucially important in determining its flow behaviour. Why is flow behaviour so important? To be commercially useful, a plastic must have suitable flow properties to be extruded or pressed into shape, as well as the strength, rigidity and impact resistance needed in the final product. The ability to flow through a die or into a mould is the characteristic of greatest importance to the polymer processor. It also controls, indirectly, the mechanical properties attained in the final product.

To obtain a free-flowing melt, characteristic of low molecular weight PVC, processors must generally utilize high polymerization temperatures. One would like to polymerize PVC at low temperatures (5°C), as this forms a high molecular weight polymer with highly desirable physical properties—but PVC is virtually impossible to process at this temperature. Thus, the flow properties of the polymer cannot be divorced from the chemical make-up of the product (the molecular weight of polymer chains, and orientation of its H-C-Cl groups). In addition, physical properties of fabricated plastic parts are very sensitive to molecular orientation, crystallinity and crystal texture—characteristics that depend upon the flow properties of the polymer. Even a modification in the design of an extrusion head can have a significant bearing on the impact strength of injection-moulded parts. Consequently, any developments which lead to improved flow properties could extend the range of physical properties attainable with PVC, and possibly, open new applications for this material.

Although polyvinyl chloride is one of the oldest and most widely used commercial polymers, efforts to understand its flow characteristics, structure and physical properties have only "crystallized" in the last decade. Considerable progress was reported at the IUPAC-sponsored 3rd International Symposium on Polyvinyl Chloride (held August 1980 in Cleveland, Ohio). Some conference speakers expressed confidence that the properties of PVC could soon be explained in terms of its complex structure. One, Dr. Michael Allsopp (of ICI Plastics Division in the UK), pointed to recent progress made by the IUPAC Commission on Polymer Characterization and Properties. Its Working Party on Structural Properties of Commercial Polymers undertook an extensive study to examine the structure of PVC, and how it affects its flow properties. Eight polymer-producing companies (in Germany, UK, Italy, France and Belgium) and one university (in the USA) collaborated in the international effort.

Structure & Properties of plastics are described in reports of IUPAC Working Parties

Structure and properties of uni- and biaxially oriented polypropylene films: Part 1—Structural characterization. Pure & Applied Chemistry, Vol. 53, No. 5 (May 1981) pp. 1011 - 1038.

A study of impact strength testing and its relevance to real mouldings. Pure & Applied Chemistry, Vol. 52, No. 12 (December 1980) pp. 2741 - 2769.

Sub-primary particles in PVC—identification and elucidation of their role during flow. Pure & Applied Chemistry, Vol. 52, No. 8 (August 1980) pp. 2033 -2050.

Collaborative study on melt rheology of styrene -butadiene-styrene block polymers. Pure & Applied Chemistry, Vol. 52, No. 5 (1980) pp. 1361 - 1386.

Effect of filler on mechanical properties of rigid PVC. Pure & Applied Chemistry, Vol. 51, No. 5 (1979) pp. 1123 - 1147.

Molecular characterization of polyethylene. Pure & Applied Chemistry. Vol. 50, No. 11/12 (1978) pp. 1715 - 1723.

Effect of molecular orientation on mechanical properties of rubber-modified polystyrene. Pure & Applied Chemistry, Vol. 50, No. 11/12 (1978) pp. 1725 -1762.

Effect of molecular orientation on mechanical properties of polystyrene. Pure & Applied Chemistry, Vol. 45, No. 1 (1976) pp. 39 - 57.

A collaborative study on tensile properties of rigid PVC: long-time transition. Pure & Applied Chemistry, Vol. 47, No. 4 (1976) pp. 333 - 339

Polymer terminology is compiled by nomenclature commission

Stereochemical definitions and notations relating to polymers. Pure & Applied Chemistry, Vol. 53, No. 3 (March 1981) pp. 1103 - 1121.

The Working Party published conclusions of their study in the report *Sub-primary particles in PVC: identification and elucidation of their role during flow* (appearing in *Pure & Applied Chemistry,* No. 8, August 1980, pp. 2033-2050). PVC samples, prepared and processed in different ways, were examined by electron microscope in the participating laboratories. All reported the smallest structural features, about 2 nm diameter, which are observed in electron micrographs of all polymers. This structure might result from random variations of molecular packing or could be an artifact of electron microscope examination, and is not thought to exert any significant effect on the flow characteristics of PVC.

Of greater importance is the effect of particles about 100 nm in diameter. Such sub-primary particles are not always observed in electron micrographs. Their visibility is enhanced when the sample has been mechanically drawn or shaped. Some investigators have argued that these particles might not be real structural features, or may be created by mechanical working. In any event, participants of the Working Party did observe sub-primary particles in their samples, and noted that extrusion of the sample did not alter their spherical shape. Based on this and other evidence, the Working Party concluded that these sub-primary particles did not deform during flow of the polymer. They feel that deformation occurs in the matrix connecting these particles. If so, the interactions responsible for the flow behaviour of unplasticized PVC must extend over distances of about 100 nm (around the same length, perhaps, as an uncoiled polymer chain).

The Working Party did not consider the effect of larger structural features in PVC: the primary particles (about 1000 nm diameter), clusters of primary particles (termed "agglomerates"), or subgrains (spherical particles which might contain 100 000 primary particles).

Members of the Working Party are presently turning their attention to the enhancement of PVC characteristics by use of acrylic processing aids. These compounds presumably alter the connective material between the 100 nm flow units. The Working Party will soon investigate changes in PVC flow properties and structure brought about when PVC is compounded with acrylic processing aids. The ultimate goal of the collaborative study is to clarify the mechanism by which PVC undergoes flow. Among the factors that may be considered are the effect of the molecular weight of processing aids, its particle size, and use of other additives of similar particle size (perhaps glass spheres, whose surface is treated for compatibility with PVC).

The same Working Party had previously considered the effect of calcium carbonate filler, mixed with PVC resin to enhance the rigidity of the finished product. They found that the incorporation of filler particles lowered the impact threshold at which cracks would appear, but increased the impact energy needed to propogate a crack. Their conclusions are presented in the report *Mechanical Properties of Rigid Polyvinyl Chloride, Effect of Filler.*

In many of their collaborative studies, the Working Party on Structure and Properties of Commercial Polymers has considered impact strength as one of the most important physical properties. Yet, as they demonstrated in another recent study, impact strength is not a single, inherent physical property of the plastic. It depends upon the size, shape and construction of the fabricated part. Standard test methods have various deficiencies, and results obtained by their use are often poor indicators of service performance. Many raw material producers have developed their own test methods to suit their special requirements, but these tests are entirely arbitrary. The overall situation is far from satisfactory.

The IUPAC Working Party set out to identify general features of moulded plastic parts that significantly affect its impact strength. Participating laboratories tested the impact strength of standard hexagonal boxes and rectangular plaques. These shapes provided corners and weld regions typical of those frequently encountered in fabricated plastic parts. The Working Party presented their findings in the report, *A Study of impact strength testing and its relevance to real mouldings.*

The Working Party on Structure & Properties of Commercial Polymers has not confined its attention exclusively to PVC, although the properties of PVC are certainly unusual and less understood than other plastic materials. The group has also studied the effect of molecular orientation on the mechanical properties of polystyrene and rubber-modified polystyrene. In conjunction with their sister Working Party on Polymer Characterization & Properties, they conducted a collaborative study on flow properties of styrene - butadiene -styrene block polymers.

Polymer chemistry working parties seek collaborators for new studies

The IUPAC Commission on Polymer Characterization and Properties presently has six Working Parties, each chaired by a member of the parent Commission. All Working Parties of this Commission welcome collaborators, but there is special need for new collaborators in four Working Parties embarking on new programmes.

Molecular characterization

Rapid and reliable molecular characterization of polymers is very important in the development of new materials, improvement in existing polymer products and in production control. Many commerically-important polymers developed in the last decade have a complex molecular structure with a very broad distribution of molecular weight, complicated branching, and differences in stereoregularity. These polymer systems can only be characterised by the use of many methods, some of which are complex, and efforts are required to ensure that consistent results are obtained by various laboratories.

So far, the IUPAC Working Party on Molecular Characterization of Commercial Polymers has examined molecular weight distributions and chain branching in a number of polyolefins. Recent work has started on the characterization of elastomers. These studies rely on gel permeation chromatography, but also utilize classical methods like viscometry, osmometry and light scattering. The Working Party intends to complete this work in the near future and consider other polymers of commercial interest.

Those interested in this programme and willing to cooperate as an active member of the Working Party are invited to contact the Chairman, Dr. Th. G. Scholte (Central Laboratory DSM, P.O. Box 18, NL-6160 MD Geleen, the Netherlands).

Polymerization kinetics

Establishing reliable data for the rates of radical polymerization reactions will be the primary goal of a new Working Party on Kinetic Parameters for Free-radical Polymerization. Eleven laboratories are presently engaged in two initial studies dealing with polymerization of methylmethacrylate and styrene.

More collaborating laboratories are needed to generate a statistically significant set of results. Those wishing to participate in this programme should contact the Working Party Chairman, Dr. G.C. Eastmond (Dept. of Chemistry, University of Liverpool, POB 147, Grove Street, Liverpool L69 3BX, UK).

Thermal properties

A new Working Party on Thermal Properties of Polymers has been formed under the auspices of IUPAC. The Working Party intends to carry out collaborative research on a world-wide scale using techniques such as Differential Thermal Analysis, Differential Scanning Calorimetry, Thermogravimetry and Thermal Mechanical Analysis. All polymer types will ultimately be included within the scope of the Working Party's studies. Results will be collected, interpreted and published.

In a first collaborative test, the glass transition behaviour of amorphous polystyrene is to be investigated by Differential Thermal Analysis or Differential Scanning Calorimetry.

All interested colleagues are cordially invited to participate in the Working Party. Please contact the Chairman of the Working Party, Prof. Dr. G. Hinrichsen (Technical University of Berlin, Institute of Nonmetallic Materials, Englische Strasse 20, D-1000 Berlin 12, Federal Republic of Germany).

Surface properties of films and fibres

Methods for characterizing common polymer surfaces is the initial focus of the new Working Party on Surface Properties of Films and Fibres. Specially-prepared films of polyethylene and polypropylene are being distributed to participating laboratories in Europe and the United States. State-of-the-art techniques, such as x-ray photoelectron spectroscopy (ESCA), are being used to characterize the surfaces. Results of the measurements will be tabulated and published. The Working Party is seeking a standard polymer surface providing reproducible results among the cooperating laboratories.

Any laboratories wishing to collaborate actively in this programme are asked to contact the Chairman of the Working Party, Prof. D.J. Clark (Dept. of Chemistry, University of Durham, South Road, Durham DH1 3LE, UK).

RECENT REPORTS

Stereochemical definitions and notations relating to polymers

This document is the first definitive statement of nomenclature for polymer stereochemistry since 1962. It is based upon prior material from the Commission on Macromolecular Nomenclature, from the Commission on Nomenclature of Organic Chemistry, and from joint IUPAC - IUB consultations on polypeptides. As far as possible, all these sources have been taken into account in arriving at recommended nomenclature for the principal features corresponding to stereoregularity in polymers.

The use of rotated Fischer projections and of zigzag representations of polymer chains is discussed, together with a set of definitions of the various types of units which must be recognised in order to generate a useful classification of polymer molecules according to the type of stereochemical arrangement. Isomerism arising from double bonds and chiral centres, or a combination of both, is dealt with, and the recommendations are extended to cover block structures as well as simple molecules. Terms describing the stereochemical relationship for sequences of units, and definitions and notations for the specification of conformations are also included.

This report was prepared by A.D. Jenkins for the Commission on Macromolecular Nomenclature, and published in *Pure & Applied Chemistry,* Vol. 53, No.3 (March 1981), pages 734 - 752. Comments may be sent to the Commission Secretary, Prof. N.M. Bikales, National Science Foundation, Washington D.C. 20550, USA

Symbolism and terminology in chemical kinetics *(Provisional)*

This report deals with the broader aspects of chemical kinetics. It suggests precise definitions of rates of consumption and formation, and of rate of reaction. It deals with empirical rate equations, and with the definitions of partial orders, overall orders and rate constants or coefficients. It suggests definitions of half life and of relaxation time. Different types of composite mechanisms are distinguished and recommendations made as to the numbering of elementary reactions in a composite mechanism. The concept of chemical flux, or chemiflux, is considered. Chain reactions, photochemical reaction, and radiation-chemical reactions are precisely defined and distinguished. Some aspects of catalysis and inhibition are briefly considered.

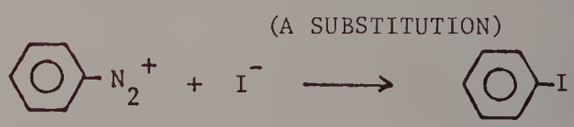
Recommendations are made with regard to the terminology to be used with reactions obeying the Arrhenius law, and similar equations that interpret the temperature dependence of reaction rates. The main theories that apply to reaction rates are collision theory, and transition-state theory, which is related to the potential-energy surface for the reaction. These theories are outlined, with recommendations as to terminology and symbols. For reactions in solution a distinction is made between mixing control (microscopic diffusion control) and microscopic diffusion control (encounter control), and the question of the degree of microscopic diffusion control is considered.

Molecular dynamics is briefly discussed, with definitions of the impact parameter, the threshold energy, reaction cross section, attractive and repulsive potential-energy surfaces, and stripping reactions.

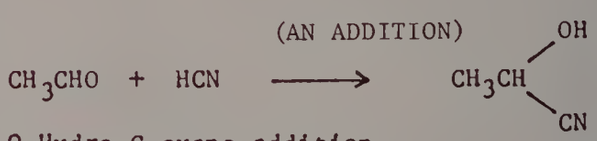
The report was prepared by Keith Laidler for the Subcommittee on Chemical Kinetics, and published in *Pure & Applied Chemistry,* Vol. 53, No.3 (March 1981), pages 754 - 771. Comments on these recommendations should be sent to Prof. Keith Laidler, Department of Chemistry, University of Ottawa, Ottawa, Ontario K1N 9B4, Canada.

Nomenclature for straightforward transformations *(Provisional)*

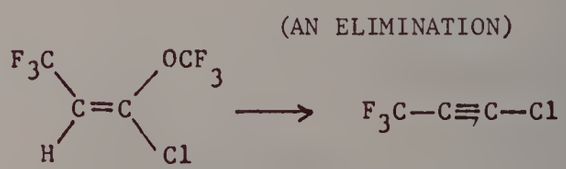
Rules for the naming of univalent substitutions, additions and eliminations are offered. The character of the rules is shown by examples:



Iodo-de-diazoniation (for speech/writing)
Iodo-de-diazonio-substitution (for indexing)



O-Hydro-C-cyano-addition



Hydro-trifluoromethoxy-elimination

In all cases, the transformation is named in basic principle by naming the groups that enter and/or depart during the reaction. The names do not report reaction mechanism, except that they should conform to knowledge of what bonds are formed or broken.

Future reports will deal with the naming of multivalent substitutions, additions and eliminations, with ring-opening and ring-closing processes, and other types.

This report was prepared by J.F. Bunnett for the Commission on Physical Organic Chemistry, and was published in *Pure & Applied Chemistry,* Vol. 53, No.1 (January 1981). Comments on these recommendations should be sent to the Secretary of the Commission, Dr. J.R. Penton, Technisch-Chemisches Laboratorium der Eidgenössischen Technischen Hochschule Zürich, Universitat strasse 6, CH-8092 Zürich, Switzerland.

IUPAC welcomes comments on its nomenclature recommendations, especially those published as provisional reports. Especially desired are comments about the use of proposed nomenclature in languages other than English. Comments should be sent to the address indicated within eight months of publication of a nomenclature report.

Pheromones are key component of new insect control strategy

Chemical insecticides have become the predominant method of insect control, but their future use is threatened by several intractable problems. The development of insect resistance to the present generation of insecticides is recognized as a growing problem. Environmental damage to wildlife, eradication of beneficial insects and contamination of food that can be caused by pesticide use are causing increasing concern.

As present insecticides become less effective, the development of new insecticidal compounds is becoming increasingly costly. The number of compounds which must be synthesized and screened to identify each new insecticide compound is growing at an increasingly rapid pace. If present trends continue, the strategy of random screening of new compounds could become prohibitively expensive and unworkable. The search for broad-spectrum insect toxicity could gradually be abandoned, and a more selective "biorational approach" adopted. This strategy will encompass a thorough study of the physiology and biochemistry of the "target" insect species. The aim will be to disrupt insect moulting, mating, eating or egg-laying. Pesticide agents developed in this way will not be subject to the major inherent limitation of conventional chemical insecticides; they will be directed against a specific species of insect, leaving undamaged the remaining ecosystem of predatory insects, birds, wildlife and crop plants.

One of the most promising and revolutionary new types of these insect control agents are pheromones. Synthetic pheromones do not kill insects, but are capable of disrupting their normal behaviour. Their composition duplicates that of natural messenger compounds controlling insect mating, foraging, aggregration or response to danger. The use of pheromones to lure insects into traps for monitoring insect populations has already been established. In this way, conventional insecticides can be directed against pests when and where they are most needed. However, the major potential role of pheromones is the *control* of insect pests. The first wide-scale tests of pheromones for insect control, now being undertaken in several countries, should prove their potential. In future, we can expect pheromones to become an increasingly important component of a new pest control strategy.

by Prof. Raymond Baker
University of Southampton (UK)
and Dr. Martin Gellender
Editor, Chemistry International

An increasing number of natural insect pheromones have been studied, identified and synthesized in recent years. The compounds which comprise insect pheromones vary widely in type and structure, but all pheromones are found to have common characteristics. Firstly, all are mixtures of compounds. Of critical importance is the relative amounts of the various compounds in a pheromone mixture. Each component must be present in the correct ratio if the pheromone is to be effective in attracting insects or modifiying their behaviour. In many insect species, some components of the pheromone mixture have little or no activity by themselves.

No less than seven compounds have been isolated as components of the sex pheromone of the female tobacco budworm *(Heliothis virescens)*. Two of the compounds can, by themselves, arouse the male budworm, but the seven-compound mixture attracts five times more males in field tests. All seven compounds have similar chemical structures. Each has a C_{13} - C_{15} unbranched carbon chain terminated by an aldehyde group or, in one case, an alcoholic group. Such series of simple, structurally-related compounds are not unusual in pheromone mixtures.

Since pheromones are carried by air currents, they must contain volatile compounds. This requirement imposes an upper limit on the size of molecules encountered in pheromone mixtures. Most have less

than 20 carbon atoms, and these are often arranged in straight-chain structures. Even with such relatively simple molecules, a large number of chemical isomers are possible (due to variation in the position of carbon - carbon double bonds and cis - trans isomerism).

It has never been doubted that animals, including insects, can distinguish between different isomers, but only recently has controversy been resolved about whether enantiomers (two compounds whose chemical structures are non-superimposable mirror images) were "different enough" to be distinguished. After all, a pair of enantiomers have identical physical properties (except that each exerts an opposite effect on polarized light), and have identical chemical properties (except when reacting with optically-active reagents). For this reason, it is very difficult for chemists to synthesize an optically-active compound or separate it from an enantiomeric mixture. Living organisms face no such difficulty, apparently because they are composed primarily of optically-active compounds. In fact, in 1971 three independent research groups demonstrated conclusively that humans perceived entirely different odours for two enantiomers. It is therefore not suprising that most insect species are similarly able to distinguish enantiomers in pheromone mixtures.

The enantiomeric composition of a pheromone component might—or might not—be critically important in determining the response of the insect. In some species, the presence of one enantiomer inhibits the effect of the other. This is the case for the Japanese beetle *Popillia joponica,* which responds to a pheromone mixture only when it contains at least 95% of the active enantiomer. This inhibition is not as pronounced in the gypsy moth, *Lymantria dispar L.* Only the (+) enantiomer in the pheromone mixture is effective in attracting moths, but the presence of the (-) enantiomer does not entirely suppress the response of the insect. A mixture containing equal amounts of both enantiomers (which is optically-*in*active) is about 10 - 20% as effective as the pure (+) enantiomer by itself.

The ability of an insect to respond very selectively to one enantiomer does not necessarily preclude the use of an optically-inactive mixture in a synthetic pheromone. In the species *Trogoderma granarium,* the male responds actively to (-)-14-methyl-8-hexadecenal, but presence of the (+) enantiomer does not interfere with the insect's response. As a final example, the ambrosia beetle (Trypodendron leniatum) responds equally well to (+)-(4,6,6,-lineatin) and to (-)-(4,4,6-lineatin). Such insect species are inherently more vulnerable to disruption of their pheromone communication, since the manufacture of a synthetic pheromone would bypass the very substantial complexity introduced when optically-active compounds are prepared and isolated.

Not all compounds comprising natural pheromone mixtures are secreted by the insect. One pheromone component of the elm bark beetle *Scolytus scolytus* (which transmits the fungus causing Dutch Elm Disease) is provided by the host elm tree. The beetles secrete a multi-component pheromone, whose effect is greatly enhanced in the presence of α-cubebene, a metabolite of the tree. The pheromone attracts male and female beetles to the tree.

Pheromones are usually produced in extremely small amounts (female insects generally produce 1 -30 ng of sex pheromone). Separating and identifying the minute amounts of compounds in pheromone mixtures pose a difficult challenge for the laboratory worker. Pheromone samples are extracted from insect glands or adsorbed from the airstream supplied to a group of insects. The components are generally separated by gas chromatography, and the structure of each component is determined by spectroscopic techniques. Mass spectroscopy is a very useful technique, as spectra can now be obtained with less than 10 ng of a compound. An NMR spectrum of a pheromone component can be obtained when 2 micrograms of the compound have been isolated.

The high activity of pheromones at extremely low concentrations is an advantage when pheromones are manufactured and deployed. Only very small quantities of a synthetic pheromone mixture are necessary

The use of pheromone traps for monitoring insect populations has already become well established. From the numbers of insects collected in traps, pest infestations are identified and located. This information is used to direct the application of conventional insectides — although in future, this information may direct the release of pheromones for insect control. Here, a pheromone trap for the olive fruit fly is shown in the leaves of an olive tree. The luring of male flies by the sex pheromone is augmented by the insect's attraction to the yellow colour of the trap.

to overwhelm natural insect communication and interfere with the destructive behaviour of the insect pest. The action of a pheromone is highly species-specific. Amounts that can disrupt mating, aggregation or other behaviour of one harmful insect species have virtually no effect on other insects, birds, animals or man. Thus, the pheromone can act in unison with natural predators of the insect pest in halting an infestation, rather than destroying and replacing them with artificial control methods. Pheromone application does not interfere with pollination and other desirable functions normally performed by insects, in a well-balanced ecological system.

Synthetic pheromones should be released continuously at extremely low rates, so that a constant equilibrium concentration is maintained by release into the air and natural degradation of the compounds. Such low-level application makes it very unlikely that agricultural workers might be exposed to dangerous concentrations (as may occur during spraying of conventional insecticides), but does present a technological challenge for which completely satisfactory methods have yet to be developed. The most common technique now used is to encapsulate the pheromone into small, hollow fibres (about 15 mm long, with an internal diameter of 0.2 mm) sealed at one end. Physical dimensions of the fibre are chosen so that pheromone vapour escapes at the desired rate. However, evaporation of the pheromone is influenced by temperature and humidity, and severe storms can blow the fibres off plant foliage and into the soil.

Such fibres are used to dispense gossyplure, the first pheromone to be registered and used commercially for crop protection. This pheromone is directed against the pink bollworm, a major cotton pest in many parts of the world. Until the late-1970's, efforts to control this insect relied on the extensive and heavy use of pesticides. To develop an alternative to conventional insecticide control, behaviour-modifying chemicals were investigated. The compound hexalure (Z-7-hexadecenyl acetate) was found to mimic the natural sex pheromone of the pink bollworm. Initial field tests showed that this compound could disrupt mating and control infestations as effectively as could conventional insecticides. Researchers later identified the true sex pheromone as an equal mixture of Z,Z-7,11-hexadecadienyl acetate and Z,E-7,11-hexadecadienyl acetate, opening the way for large-scale production of a synthetic pheromone. In subsequent wide-scale field tests in the southwestern United States, bollworm infestations were controlled with a substantial reduction of insecticide usage and overall pest control costs. These tests demonstrated that gossyplure, encapsulated in hollow fibres, could be an extremely valuable part of an integrated pest management strategy for cotton.

It is perhaps surprising that the first synthetic pheromone products achieved commercial success and wide use only within the last 3 years. After all, the substantial advantages and enormous potential for pheromone use were recognized years ago. Detailed knowledge is already available about the composition and chemical structure of many naturally-occurring pheromones. So, why has the introduction of commercial pheromones progressed so slowly?

The development and production of pheromones present entirely different commercial considerations that are faced by manufacturers of commercial insecticides. A major investment of effort and money (about US$1.5 million, according to one 1978 estimate) is required to synthesize pheromone components for field testing, formulate a product with maximum effectiveness, test the efficacy under actual field conditions, study its environmental effects and toxicology, and develop a process for commercial manufacture. A comparable research and development effort is required for conventional insecticides, but here, the initial investment can generally be recovered by large-scale manufacture and world-wide sale. Not so with pheromones, which are produced on a small scale, usually by specialised companies with expertise in organic chemical synthesis. Because of the small amounts of synthetic pheromones that are needed—even for an extensive insect control programme, the prospects for lucrative manufacture are poor. For this reason, major manufacturers of crop protection chemicals are reluctant to become involved with pheromone production. Government agencies and universities will likely continue to be the primary proponents of pheromone research and development.

Pheromone use might ultimately be confronted by the same limitation that threatens the viability of conventional insecticides: insect resistance. Prolonged heavy reliance upon pheromones will subject the target insect species to strong selection pressures. A few insects will likely produce, and respond to, pheromone mixtures of slightly different concentration. These individuals could bypass the disruptive effect of an artificial pheromone, and pass this capability on to their offspring. The pheromone composition of each succeeding generation would tend to drift away from that initially found to have the greatest effect on the insect species.

Thus, the need for pheromones research will not end when a pheromone system is developed and perfected. Trained individuals must supervise the application of pheromone systems. As with conventional insecticides, pheromones should be used for insect control only when they are needed, and only to achieve the degree of insect control that is necessary. The effectiveness of the pheromone mixture must be periodically monitored, and its composition may need to be adjusted.

Insect control with pheromones appears to be especially attractive for developing countries. Pheromone development, monitoring and manufacture are relatively labour-intensive, but require only small quantities of chemicals. Countries with skilled scientific staff and access to sophisticated analysis instruments, but with little foreign currency to import pesticides and other chemicals, would be ideally placed to conduct pheromone research programmes, and to develop and utilize new products.

Pheromones lure fruit flies in Spanish field trials

The olive fruit fly *(Dacus Oleae)* is widely distributed throughout the Mediterranean basin and parts of North Africa. It is the major pest of olives, having its most serious effects in Italy, Spain, Greece and Israel. The main means of control is by insecticide sprays. To monitor populations of the pests, traps are used to collect fruit flies. In the past, these traps relied entirely on the attraction of the flies to food bait and the yellow colour of the traps.

By 1974, researchers studying the olive fruit fly had discovered that the female produces a volatile pheromone that attracts males. The compound (Z)-non-6-en-1-o1 was found to attract male flies, but other compounds were thought likely to be present in the pheromone. The research group at Southampton University have now identified and synthesized the major component of this sex pheromone. Rectal glands of adult male and female flies were dissected, sealed in glass capillaries and subsequently analyzed by gas chromatography. One compound was found to only be present in gland extracts of females, at a level of about 0.3 micrograms per fly. The mass spectrum of this compound indicated the molecular formula $C_9H_{26}O_2$, and suggested the structure of a spiroacetal. The structure of 1,7-dioxaspiro (5,5) undecane was confirmed when this compound was synthesized and purified, providing a mass spectrum that was identical to that of the insect pheromone.

Whether the natural pheromone contains one enanitomer of this compound or a mixture of the two optically-active isomers has yet to be determined, but a mixture of both enantiomers has shown high activity in preliminary field trials undertaken last year in southern Spain. Traps impregnated with 25 milligrams of spiroacetal mixture attracted four times more male flies than traps which depended entirely on attraction to the yellow colour. The effect of the pheromone and attraction to yellow acted in synergism; the greatest yield was obtained in yellow traps impregnated with pheromone. The number of insects lured into the traps was not altered by the ad dition of the previously-identified attractant, (Z)-6-nonen-1-o1.

The sex pheromone of the olive fruit fly is the parent compound of a class of spiroacetal compounds previously unknown in insects. Whether the natural pheromone contains one enantiomer of this compound, or a mixture of the two optically-active isomers is not yet known, but a synthetic mixture containing both enantiomers has shown high activity in attracting the male fly.

Other spiroacetal compounds are used for communication in other insects species. One such compound has been identified as the major component of the aggregation pheromone of a bark beetle *(Pityogenes chalcographus).* Another is secreted by the common wasp, *Paravespula vulgaris,* and apparently acts as an aggression inhibitor. However, the 1,7-dioxaspiro (5,5) undecane pheromone of the Olive Fruit Fly is the first spiroacetal to be identified as a specific insect sex pheromone, and is the parent compound of a class of spiroacetals previously unknown in insects.

The olive fruit fly (above) is a major pest in the Mediterranean Basin and parts of North Africa. To prevent damage to their olive crop (such as shown on left), farmers have been dependent on insecticide spraying.

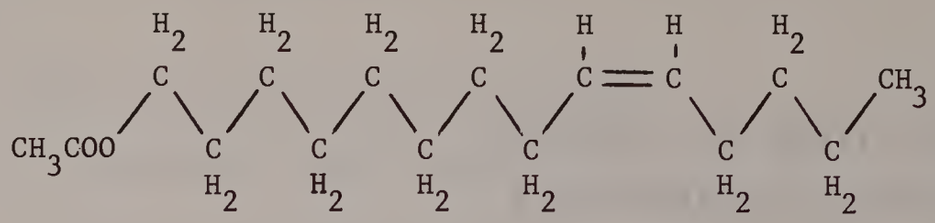
Forest destruction may be halted by monitoring insect populations

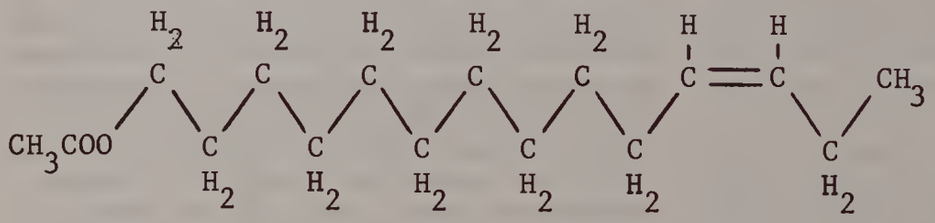
The life-cycle of the Pine Beauty Moth *(Panolis flammea Schiff)* is closely tied to the pine tree *Pinus sylvestris.* In late March and April, adult moths emerge from pupae which have survived the winter in the soil. The female releases a sex pheromone to attract males. Mating occurs in the crown of the trees, and eggs are laid on pine needles. When these hatch in late May or early June, the young larvae feed on fresh pine shoots, but later move onto older needles. Eating of young and old foliage by large numbers of larvae can cause death of the tree.

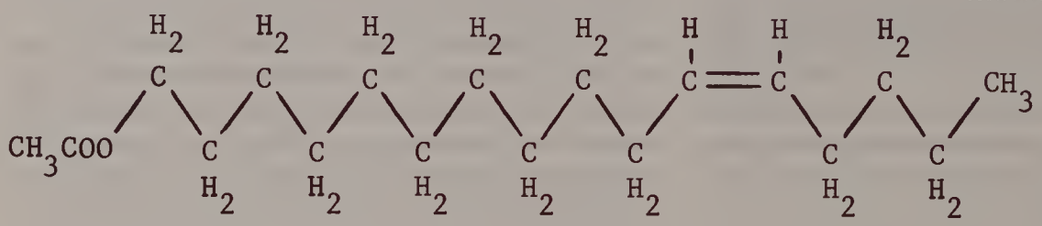
The number of moths varies greatly, with enormous differences occurring in different forest areas and from year to year. Sometimes, the insects pose no significant threat, while in other years, the pine beauty moth can cause devastating outbreaks—as it has in central Europe, and more recently, in some localized areas of Britain.

Rather than relying on widespread use of insecticides to control the pest, the UK Forestry Commission has been developing a monitoring system to pinpoint those forest areas most at risk, and providing early warning of population increases. Initial studies were undertaken to identify compounds which could attract the moths into traps. A number of tetradecenyl acetate compounds elicited an electrophysical response in the insect antennae. Those compounds that had the highest activity were all aliphatic acetates with similar chemical structures: most contained a C_{14} hydrocarbon chain with one or two double-bonds. Among the most effective compounds, Z-9 and Z-11 tetradecenyl acetate provided markedly increased activity when both compounds were present in a mixture. Indeed, certain mixtures of the two compounds were found to be distinctly more effective than others in luring insects into traps.

Infestations of the pine beauty moth can devastate areas of pine trees. The adult moth (shown in photo above right) attracts its sexual partner with a pheromone mixture, and mates in the tree. Eggs laid on the pine needles hatch into larvae which feed on the fresh pine shoots (photo lower right). When large numbers of larvae are present, much of the foliage is eaten and the trees may die. Entire areas of pine trees may be defoliated or destroyed during severe infesations (photo left).







The sex pheromone of the pine beauty moth contains three structurally - similar compounds. Z-9 and Z-11 tetradecenyl acetate, which differ only in the location of the carbon-carbon double bond, were suspected to be pheromone components when they were found to elicit a response in the antenna of the moth. Certain mixtures of the two compounds provided markedly enhanced activity, while other mixtures had virtually no effect. The presence of a third compound, Z-11 hexadecenyl acetate (structure below), was revealed by chemical analysis of pheromone extracted from the moth.

While field workers were beginning to evaluate these attractant mixtures, other researchers were analyzing those compounds that were naturally secreted by the insect. An extract derived from about 3000 female moths was examined by gas chromatography and mass spectrometry, yielding partial identification of at least twelve components. A series of saturated and unsaturated methyl octadecanoate esters were present in relatively large amounts (of the order of micrograms per insect), but these compounds were not thought to be involved in the sex pheromone system. Tetradecenyl and hexadecenyl acetate were also identified. The gas chromatograph peak corresponding to the tetradecenyl acetate appeared to contain more than one isomer, but the composition of the tetradecenyl acetate mixture could not be derived by mass spectrometry. The position of the carbon - carbon double bond in the C_{14} chain could only be inferred by using other techniques. These suggested that the pheromone mixture contained Z-9 and Z-11 tetradecenyl acetate and Z-11-hexadecenyl acetate in the ratio of 100:1:5.

The effectiveness of three-component pheromone mixtures will be evaluated in field studies this year. It is hoped that these pheromone mixtures will enable field workers to monitor insect populations with greater accuracy and reliability. In addition, preliminary efforts to disrupt mating of the pine beauty moth are also being attempted. If successful, these studies could lead to the development of synthetic pheromone systems to control infestations of this major forest pest.

Small, multi-product chemical plants use scaled-up laboratory synthesis

The general trend in the chemical industry has been towards larger and larger manufacturing plants. For some chemicals, a few world-scale plants now provide the entire global demand. This trend has been accompanied by a divergence of chemistry and chemical engineering, reflecting the very different conditions that are used for chemical synthesis in the laboratory and in massive commercial chemical plants.

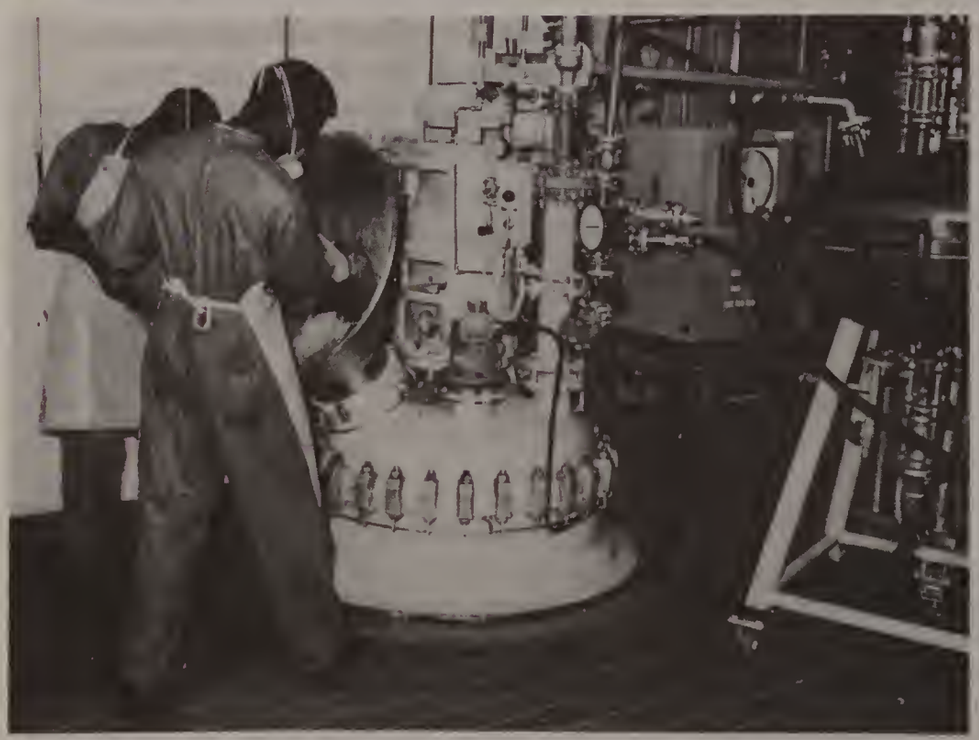
Hidden beneath this massive drift towards concentration of chemical production within a few industrial centres, an undercurrent has been developing within the last decade. Small, highly flexible chemical plants have been built to manufacture a wide range of chemicals. These plants are intended to meet the indigenous chemical requirements of a small industrialized country or a fledgeling chemical industry in a developing country.

Economics of scale dictate that such small chemical plants cannot compete directly against mammoth world-scale plants. The South Africans have become leaders in the operation of small multi-purpose plants because these can provide a reliable supply of chemicals, independent of trade restrictions and disruptions to foreign chemical supplies. However, as these plants prove their suitability for providing limited amounts of a broad range of chemicals, the concept of the small, multi-purpose chemical plant will probably take root elsewhere.

Conditions in the international chemical marketplace might now favour the characteristics offered by the small, multi-purpose plant. For one thing, multi-purpose plants provide flexibility, and can adapt quickly to produce new products which are in great demand or to use alternative raw materials. While the small multi-purpose plant is relatively labour-intensive (requiring more man-hours of operating personnel for each unit of product produced), this drawback has become relatively less important in relation to the cost of chemical reactants. Efficient use of chemical feedstocks has become the criterion of prime importance, and in many cases, the small multi-purpose plant can probably match the reaction yield of a large chemical plant.

Particularly in developing countries which lack foreign currency to pay for imported chemicals, an indigenous mini-chemical industry operating with local labour might provide significant advantages. Here, the introduction of new chemical syntheses based on biotechnology may prove a real boon, since fermentation methods are well suited for small-scale applications. Such applications were among those considered at a seminar on the "Prospects for Small-scale Chemical Industries in Developing Countries", held with the 1st International Chemistry Conference in Africa (held in Nairobi, July 1980). Seminar participants recommended that small-scale chemical industries should be developed in Africa to help meet development objectives. As specific examples, the participants cited the isolation of pharmaceuticals and other chemicals from agricultural plants and the gasification of agricultural residues. Another likely application is the production of polyethylene from plant carbohydrates (by polymerization of ethylene made by dehydration of fermentation ethanol).

The concept of a small multi-purpose chemical plant might best be illustrated by the Ciba-Geigy pharmaceutical plant in South Africa. Its reactors and purification equipment, which offer the flexibility to produce an enormous range of pharmaceutical products and intermediates, essentially duplicate the techniques used for laboratory synthesis. "One-step" reactions are carried out in glass-



Flexibility to produce an enormous range of pharmaceutical products and intermediates is incorporated into Ciba-Geigy's multipurpose plant in South Africa. The plant, shown above, has five reactor vessels for conducting one-step syntheses, purification equipment, a utilities unit (providing heating, cooling, compressed air and vacuum), effluent treatment and an analytical laboratory. Operations, such as loading crude reagent for purification, shown on left, are done on a scale about 1000 times larger than is typically used in laboratory synthesis.

lined and stainless steel reactors. Each is equipped with a reflux condensor, can operate at pressures up to three atmospheres and temperatures up to 100°C, and can be connected to scrubbers, adsorption columns and condensor units. Clarifying filters can be transported around the plant and connected with flexible couplings to any of the reactors. For vacuum filtration, porous ceramic tiles are used as the filter medium in vacuum filters that are essentially oversized Buchner funnels.

The plant has facilities to provide -40°C brine, deionized water, compressed air, cooling water, vacuum (with anti-pollution pumps) and effluent treatment. Synthesis and purification are carried out on a scale about 1000-fold larger than would typically be used in a laboratory. Various operations can be carried out to isolate products from reaction mixtures, including distillation, crystallization, phase separation, ion exchange, centrifugation, filtering and drying. Reaction conditions are closely controlled. An analytical chemistry laboratory with a staff of 15 monitors the composition of raw materials, intermediates and products.

The advantages of multi-purpose chemical plants became apparent to Ciba-Geigy after many years of pharmaceutical manufacture in South Africa. Producing drug products for the small, but diverse, South African market presented economic difficulties that could not be overcome by conventional approaches. In 1965, Ciba-Geigy commissioned a

plant dedicated to the production of phenylbutazone, but within ten years, the market for this compound declined as there was a switch to other drugs. After building a small plant in 1975 to make the chemically-similar compounds cyclopenthiazide and hydrochlorothiazide, Ciba-Geigy became committed to the multi-purpose concept for meeting the South African pharmaceutical market. Process design for the multi-purpose plant was finished in 1978, and the plant began operation in 1980. By the end of 1980, about 70% (by value) of Ciba-Geigy pharmaceuticals used in South Africa were made in the country—most by the multi-purpose plant. Initially, only products that have been developed and patented by Ciba Geigy are being made in the multi-purpose plant. The plant, however, does have spare capacity which will likely be used to manufacture additional products under contract for other pharmaceutical companies. By installing more reactors in the same plant and operating them continuously, the capacity of the plant could be increased to over 60 tons/year. The plant is proving so successful, one South African technical consultant stated to *Chemistry International,* that Ciba Geigy will use it as a model for other developing countries.

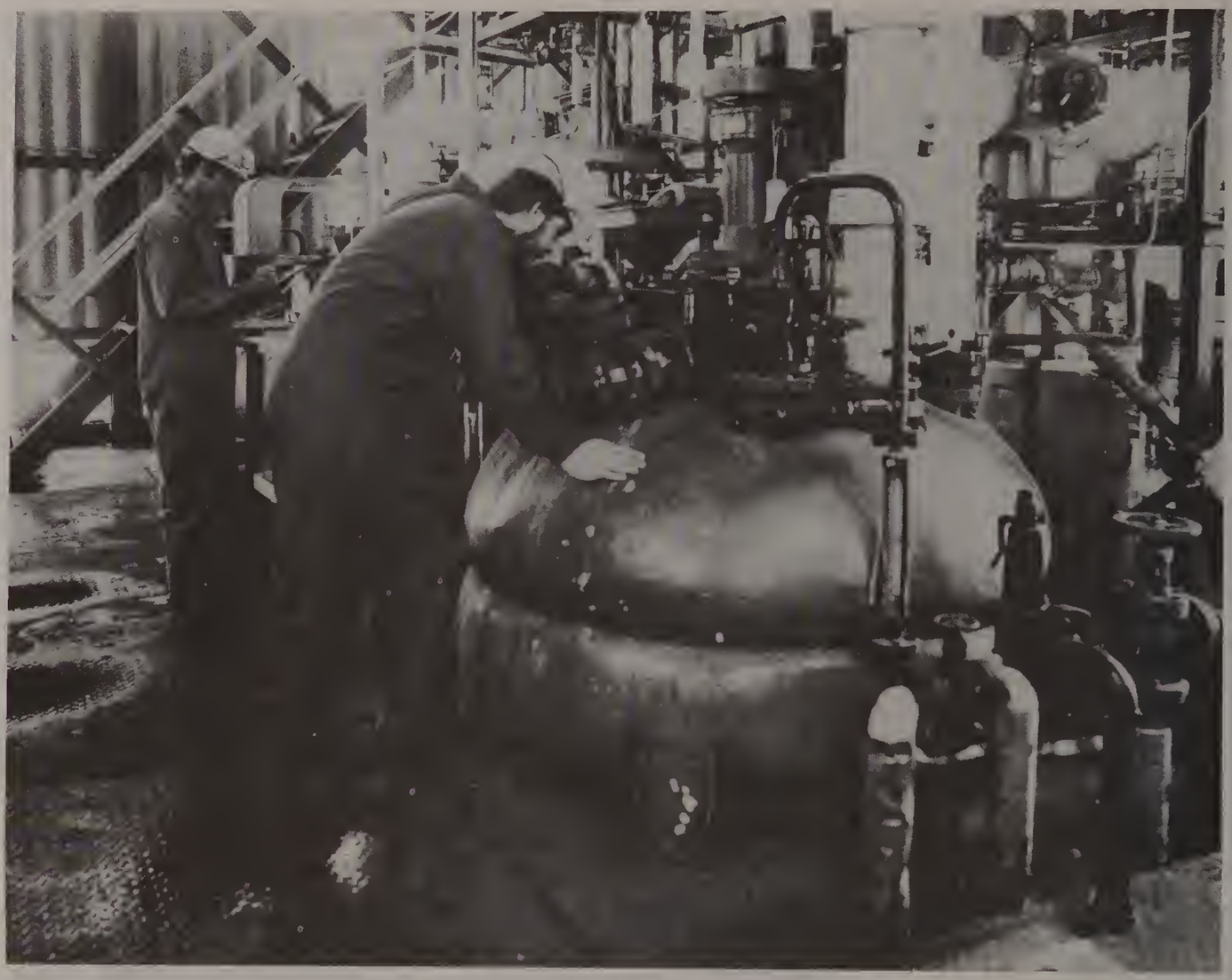
Another multi-purpose plant, operated by Safripol in South Africa, is thought to be the only polymer manufacturing plant in the world whose reactors have the capability to polymerize ethylene or propylene. It provides a complete range of injection-moulding, blow-moulding and extrusion grades of high-density polyethylene and polypropylene. Since its initial construction in 1972, the plant has been expanded and modified. A further expansion now underway will raise its production capacity to 80 000 tons/year of high-density polyethylene and 44 000 tons/year of polypropylene, about 2½ times the original output of the plant. Use of a third-generation catalyst is being considered to increase the capacity of the plant even further, although Safripol is reluctant to disclose technical details.

In Canada, a multi-purpose plant is producing more than 200 different types and grades of polymer resins that are needed for the formulation of paints, varnishes, printing inks, synthetic rubbers and glass-reinforced plastic parts. This small plant is able to provide nearly the entire range of polymer resins required by Canadian industry. Built by Ashland Oil Canada's chemical division in 1976, the plant produces polymer resin in three reactors. Each is a general-purpose chemical unit, and is fitted with ancillary equipment enabling it to operate within a wide range of temperature, pressure and reactants. More than forty liquid reactants can be supplied to the reactors from the main storage tanks, and solid materials can be dispensed from 200-litre drums and delivered to the reactors through pneumatic conveyors.

Like any multi-purpose plant, the Canadian polymer resin plant depends for successful operation on its inventory control system. At any one time, there may be *8000* drums of raw materials and products in the plant (and probably more since the plant was expanded in 1978). The three reactors are operated on a weekly schedule, which is carefully planned to avoid inter-batch contamination.

Flexibility of reaction conditions is of paramount importance. Each reactor may be called upon to produce polyester, phenolic, alkyd, urea-formaldehyde or acrylic resins. Depending upon the type of polymerization, the reaction may absorb or liberate heat. The reactor may need to be heated as high as 275°C by circulating hot oil through a heating jacket, or it may need to be cooled with cold water. It may be necessary to apply vacuum to remove water produced by the reaction. In other cases, water vapour is flushed from the reactor by boiling of a volatile solvent (which is refluxed and returned to the reactor). Still other polymerization reactions produce no water or vapours, and may need to be protected from air-oxidation with a blanket of inert carbon dioxide gas. Before any new resin formulation is made in one of

Polyethylene or polypropylene can be made in the polymerization reactors of Safripol's multi-purpose plant, now undergoing expansion.



AECI's multi-purpose organics plant presently produces toluene and xylene sulfonic acids, di- and triacetin, and a proprietary PVC additive in two glass-lined reactors (one in foreground of above photograph). The company is also planning to manufacture sulfonate detergents in the same vessels. A third reactor has been installed recently to make quaternary ammonium compounds.

the 18 kilolitre reactors, polymerization procedures are worked out in a 400 litre test reactor.

The multi-purpose concept has also gained favour with the South African company AECI, which has just completed a small multi-purpose plant to make toluene and xylene sulfonic acids (for the foundry industry), aliphatic esters and quaternary ammonium compounds (for use as fabric softeners). The production of sodium xylene sulphonates for the detergent industry, and other products, is also planned. AECI's multi-purpose organics plant began operation in early 1980, and was described in the June 1980 issue of *CHEMSA* (journal of the South African Institute of Chemical Engineering). Dries Nieuwoudt, Manager of AECI's Chloralkali and Organics Division, stated his company's view that "The multi-purpose concept is the most economic way that a developing country, with its small market, can produce speciality chemicals." But, he pointed out, "Technology for this sort of operation cannot be bought; it has to be developed."

AECI's multi-purpose organics plant, located at Modderfontein (South Africa), has three reaction systems, each served by a glass-lined stirred reactor. Depending upon the reaction carried out, the reactors can be heated or cooled, operated under reduced pressure, or connected to glass fractional distillation columns.

AECI, an IUPAC Company Associate, also operates two other multi-purpose type plants. One makes peroxides, which are mostly exported and used for plastics manufacture. Another plant (operated as a joint venture with another company) manufactures organic pigments.

Yet another multi-purpose plant is the agrochemical production unit now being built by KOP (Klipfontein Organic Products Corporation in Johannesburg). It reportedly will produce pentachlorophenol, MCPA and 2,4-dichlorophenoxyacetic acid.

This special feature was originally published in *Chemistry International,* 1980, No.2. It elicited an unprecedented response. Nearly 5000 reprints of the article were purchased. It has since been translated into French and published in *L'actualite chemique,* March 1981. For the benefit of lecturers at the IUPAC Congress and others who have not seen the article before, and for those who will listen to their conference lectures, the article is published again here.

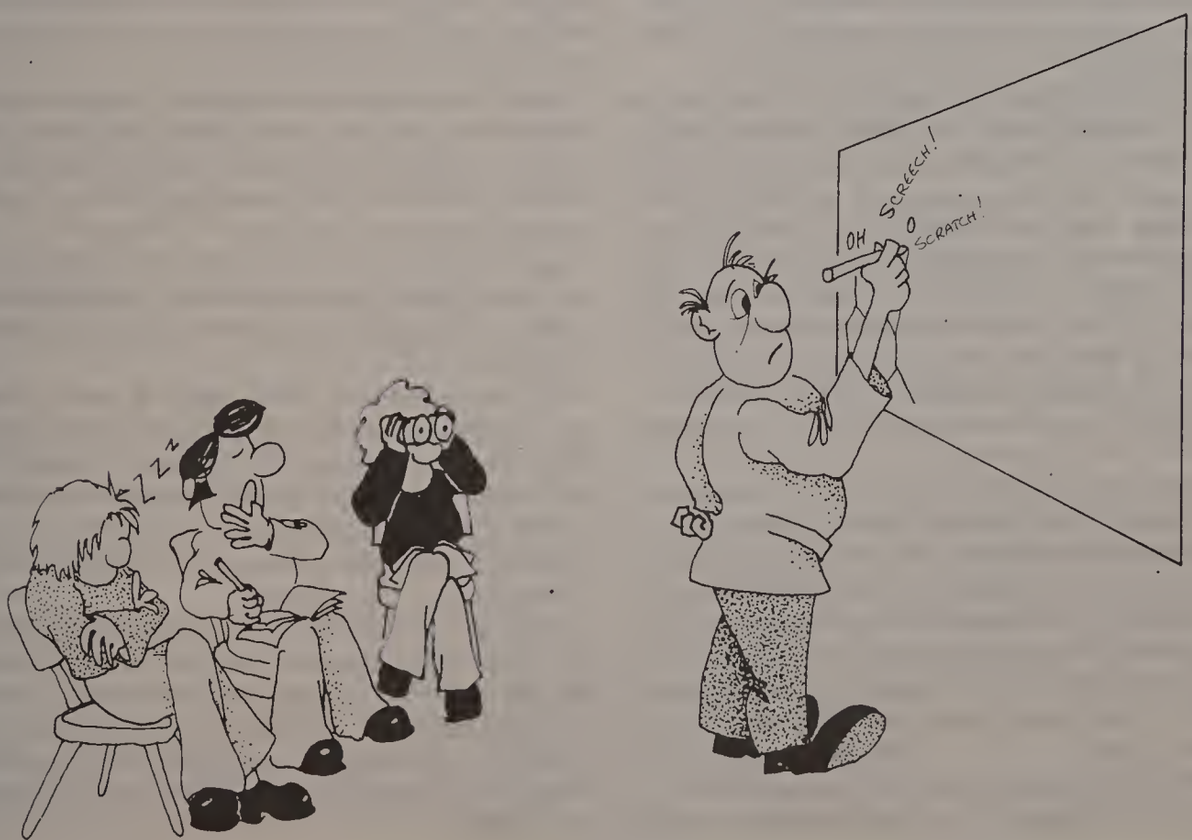
Presenting your research results

A manual for chemists presenting papers at international chemistry conferences

No method of presenting research results of individual views can have more impact, and arouse more attention, than a face-to-face presentation at a major chemistry conference—be it as a plenary lecture, poster presentation or a short talk. But on the other hand, nothing can be more boring than a speaker who has not organized his material, shows slides so crammed with data as to obscure meaningful conclusions, and drones on past his alloted time in a monotonous voice.

The following article is a guide to help you present your results, conclusions and views at chemistry conferences. It provides helpful hints in preparing your presentation and alerts you to common pitfalls to be avoided. Many of the suggestions are simple... perhaps obvious. Yet, these same mistakes are repeated at nearly every conference, undermining the interest and understanding of the audience. Attention to these points could make your work better understood and recognized by chemists throughout the world.

The guide is based upon three essays written by Guy Ourisson, secretary-general of the IUPAC and Professor at the Institut de Chimie of the Université Louis Pasteur in Strasbourg, France.



I. SPEAK

Speak . . . but not yet. You have just been given the word by your chairman. Wait until your projectionist has prepared your slides. Wait until you can safely speak, then start.

Start by stating what you are going to talk about, then talk about it, then summarize what you have been talking about.

Never assume that anybody in the audience is a fan of yours, knows your work, is familiar with your publications, and expects you to divulge only brand new results. Always place your subject in a general perspective and explain why you have taken it up. Describe briefly your methods and results, and describe clearly your conclusions.

During your lecture, as well as during the discussion, talk to the person sitting on the farthest bench, not to your chairman or your supporters in the front seats. You can safely assume that this back-bencher is not competent in your field, but that he hopes you will make him understand your work. Make sure he hears and understands you. Never speak to the blackboard. If your lecture room is equipped with microphone and loudspeakers, avoid the ear-piecing squeak obtained when noise from one loudspeaker is picked up by the mike: don't let the microphone come close to the nearest loud-speaker. Always speak near, but away from, the mike, and never, never touch it, move it, or drum on it. Or else, forsake the microphone and speak LOUDLY.

If your lecture is to be simultaneously translated, contact the translator before your lecture. Give him a related text or list of most specialized words you are going to use. Offer him your help in advance.

Never read a text: nothing can be more efficiently boring. If you do not feel secure, use slides *with text* to prop you up, but again do not read them aloud but comment on them. Most likely, everybody in the audience is literate.

When said in public, some words leave no mark in anybody's mind. Never use them without having written them on the blackboard or on a slide. Foreign family names can be pronounced in so many different ways. Dates and numerical values too should be written: in an international audience, some will mistake fifty-two for tweny five (fünf und zwanzig). Anyway, it is best not to use numerical values unless they pertain *directly* to your discussion. Otherwise, who in the audience would care for the value of a melting point, specific rotation or nmr chemical shift?

Another don't: never, never utter a systematic IUPAC name; it is bad taste. IUPAC names are not intended to be used in that way. Passport numbers are also systematic, unambiguous, useful descriptors of individuals, but who would call his girl friend by her passport number? And anyway, the audience will be informed just as well by saying "this unsaturated ketone..." while pointing to a formula on a slide or the black-board.

Stick to the allotted time. It is a good idea to rehearse your lecture once, in full, in front of critically-minded friends and a clock. It is said that a new President or Prime Minister has 100 days to show what he can do. You have 20 minutes at most. If your lecture is scheduled to last 45 minutes, the last 25 minutes will be useful only if you have managed to interest your audience in the first 20. If you are an unusually effective lecturer, nobody will notice if you overshoot the limit by a few minutes. But if you babble well past the limit, you are sure to antagonize the next speaker, the session chairman, and the rest of the audience. Obey automatic warning lights if they are in use, or use an alarm watch.

Now a few words about light arrows, which are meant to show one point on a slide, and then disappear. An illuminated arrow will be more apparent on any *other* surface than a bright projection screen: turn it off when not in use. Otherwise, you are likely to draw the attention of the audience around the lecture hall, across the ceiling and onto a pot plant.

When you reach the end of your lecture, conclude briefly, clearly and *explicitly*. The audience must know when to applaud, or at worst, when to wake up.

Finally, if you must speak in English, and if you really can't, try to enlist an English-speaking colleague to help you with your lecture, at least to correct the key words you will be using constantly throughout your talk.

II. SHOW (SLIDES)

Lecture slides are the *easiest* way to communicate information under the conditions of a conference lecture. The *best* way is probably with blackboard and chalk, but their use at a symposium requires experience, ample blackboard space, and a suitable lecture topic. It is commendable when done well, but is generally not recommended.

Slides are invaluable to highlight important points of your lecture and show material which could not easily be explained. But slides should not normally be used to reproduce what you say, and never should be read on the screen.

Lecture slides must be legible and understandable. Any slide which cannot be read by everyone in the audience, including those in the back row, should not be projected.

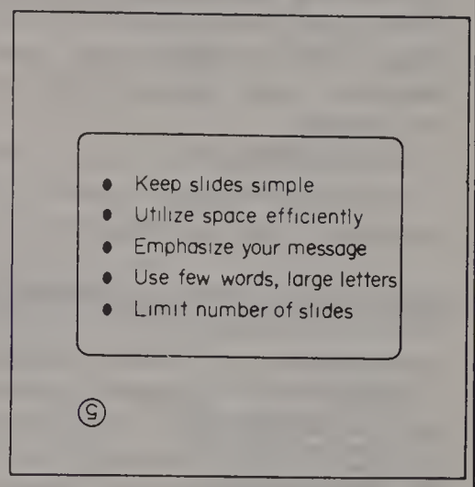
The first condition for legibility is that the entire slide must be projected on the screen. This sounds trivial, but it is common for lecturers to insert "vertical" slides amongst those oriented horizontally, and project these partly on the ceiling. This may be avoided by preparing all slides "landscape" fashion, to be projected horizontally.

Another condition for legibility is that lettering should be large and lines should be thick (thicker than for a printed figure). Any slide which cannot be read with the naked eye when held in your hand will probably not be legible when projected on a screen. This is a stringent test for legibility; but it is simple, and it works.

Viewing this slide from a distance of about 25 cm gives an indication of how it might appear on a projector screen from the rear seats of a lecture room.

Guidelines for preparing good slides are offered in "Preparation of Slides; A Guide for Authors", by the International Federation of Automatic Control. Among their recommendations:

(1) A good slide should convey a single, significant message to support the oral presentation.
(2) It is usually advantageous to simplify tables, graphs, diagrams and drawings. Additional information may be presented orally.
(3) Tables are recommended only if the information cannot be portrayed graphically.
(4) Do not reproduce material from printed publications unless it is suitable. In most cases, printed illustrations contain too many details.
(5) Use a lettering guide (stencil) for text. Allow additional spacing between words and lines.


• Keep slides simple
• Utilize space efficiently
• Emphasize your message
• Use few words, large letters
• Limit number of slides
5

Another helpful suggestion is to put a numbered self-adhesive label on the lower left-hand corner of the slide (when the slide is viewed as it is to appear on the screen). This makes it simple to keep the slides in order, and ensure that the slide will be projected right-side up. When the slide is correctly loaded into the projector, the label will be covered by the projectionist's right-hand thumb.

For all art-work, use a standard A4 page (180 x 240 mm), never a larger format. On this size page, you can draw formulas of the correct size using commercial stencils (made by such companies as Verlag Chemie, Merck, Darmstadt, etc).

Restrict the amount of information on each slide. Aim at "one information bit" per slide, and do not hesitate to split a set of data onto two slides. To avoid cramming too much information on each slide, you should limit yourself to a maximum of 20 - 25 words per slide.

Do not include any information on which you will not comment—nomenclature, melting points, bibliographic references. Think twice before you show an n.m.r. spectrum or a chromatogram (is it really novel?) Trim your slides of unnecessary "noise" (information with no apparent purpose). Never show tables of figures (although you may safely do so if the table is so simple as to comply with the 20 - 25 word/slide limit).

Legibility does not imply professional artwork, although modern transferable lettering (such as Letraset, Decadry, etc) allows chemists to make drawings and legends with a professional look. Casual, free-style lettering and drawings can be as effective and much quicker to prepare, but you must have readable handwriting and some deftness at free-hand art. Try it once, and have it evaluated by friends before you expose it to your conference audience.

Slides are especially valuable if you are about to give your lecture in a language you have not fully mastered. In a few lines, you can summarize your problem, your methods, your results, and your conclusions. Grammatical errors can be eliminated beforehand by having slides checked and corrected. Your audience will find it much easier to follow your talk.

Different styles of slides each present advantages and drawbacks. For example, slides with black figures on a white background show dust more than white-on-black slides, but are easier to read. The major limitation on quality of any slide system is the experience, equipment and care of the photographer. Consult him; he will know which type of material will reproduce best and be most legible. You might also read several articles that provide guidance (the pamphlet "Slides with a purpose" is available free-of-charge from Dept. 55Z, Kodak Inc, Rochester NY 14650, U.S.A.).

The same slide may be needed twice, or more, during your talk. For slides you expect to show repeatedly, have two or more copies prepared rather than hope the projectionist will be able to find "slide 15" in the dark.

Identify the orientation of your slides with a clearly-seen dot or label on the frame, easily visible in the dark. This is absolutely necessary if only a manual projector is available, and could be helpful even if an automatic projector is used.

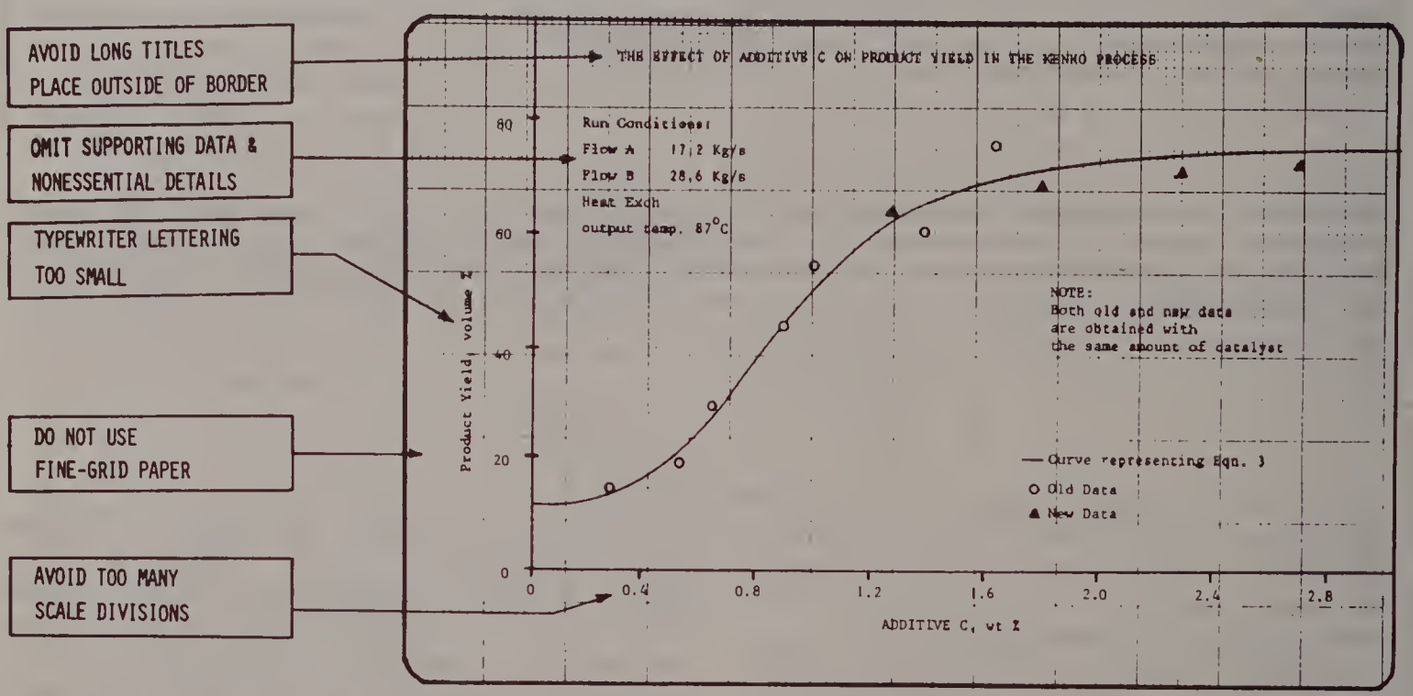
Well before your lecture, contact the people in charge of the lecture room. Introduce yourself to the projectionist; much of your success will depend upon him. Ask how he prefers you to call for the next slide, and check which trays are available. Place your slides *yourself* into the trays, checking their orientation, and deciding whether complete darkness or dimmed lights are preferable. Check the quality and size of the image on the screen. Then, if the slides prove unacceptable for the available conditions, your talk can still be salvaged with an overhead projector or blackboard and chalk.

It is amazing that even some well-seasoned lecturers are apparently quite happy to let a bored pro-

jectionist ruin their presentation by showing slides improperly focussed, in the incorrect order, and with repeated pleas for the next slide. Even worse is the time and attention of the audience dissipated in exploring the seven wrong orientations which are possible for a slide, before the correct one is discovered by chance. Such problems are usually avoided by discussing your slides with the projectionist beforehand.

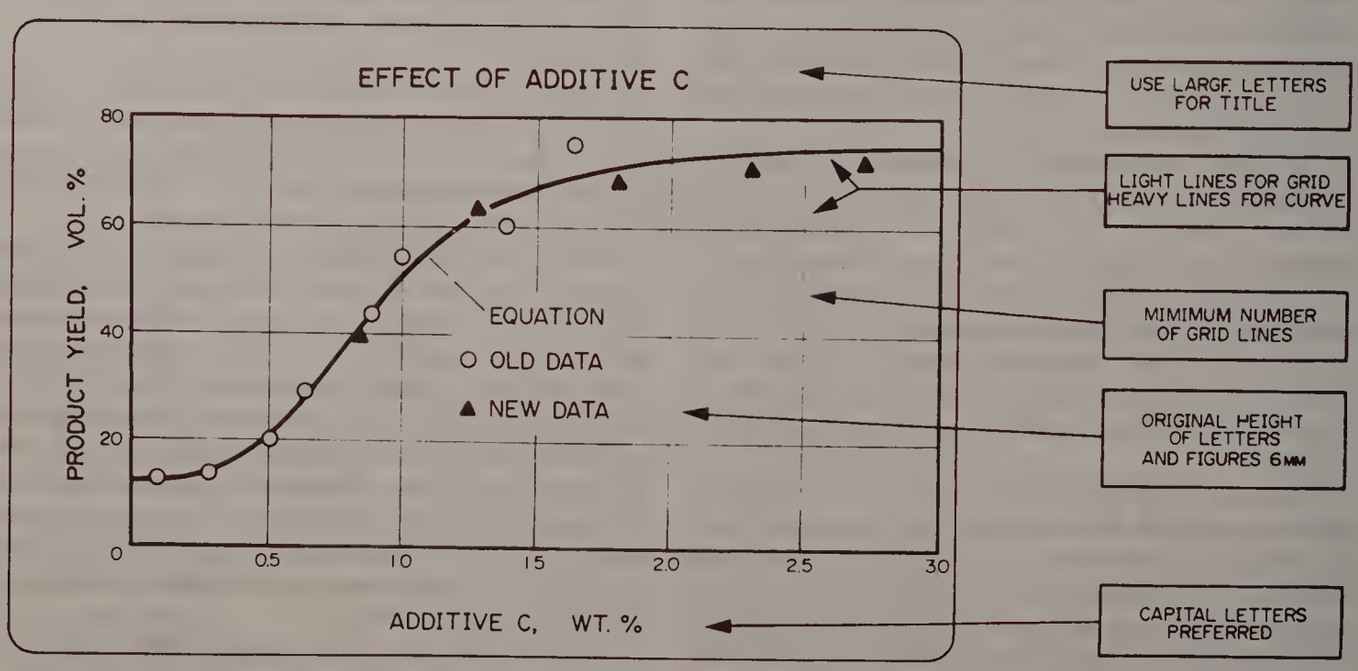
The most likely point during a symposium for major trouble is the Opening Lecture. It is then that the conference organizers are likely to discover that the screen is too small, there is no coloured chalk, and no spare projector bulb, the lights cannot be dimmed, or the microphone does not work. Do not despair! If you are the opening lecturer, you need no advice. No doubt, your ability to survive such ordeals has been a major factor contributing to your recognition and high regard to the chemical community, and to your invitation to present a conference lecture.

Example of a **poor slide** illustration


AVOID LONG TITLES
PLACE OUTSIDE OF BORDER
OMIT SUPPORTING DATA & NONESSENTIAL DETAILS
TYPEWRITER LETTERING TOO SMALL
DO NOT USE FINE-GRID PAPER
AVOID TOO MANY SCALE DIVISIONS
THE EFFECT OF ADDITIVE C ON PRODUCT YIELD IN THE KENKO PROCESS
Run Conditions:
Flow A 17,2 Kg/s
Flow B 28,6 Kg/s
Heat Exch
output temp. 87°C
NOTE:
Both old and new data are obtained with the same amount of catalyst
Curve representing Eqn. 3
Old Data
New Data
Product Yield, volume %
ADDITIVE C, wt %

The two slide drawings shown here depict the same material, but the one below has been redrawn for simplification and clarity. Explanatory details and supporting data that have been omitted can be presented verbally if necessary or if requested. *(Adapted from "Preparation of Slides: A Guide for Authors".)*

Example of a **good slide** illustration

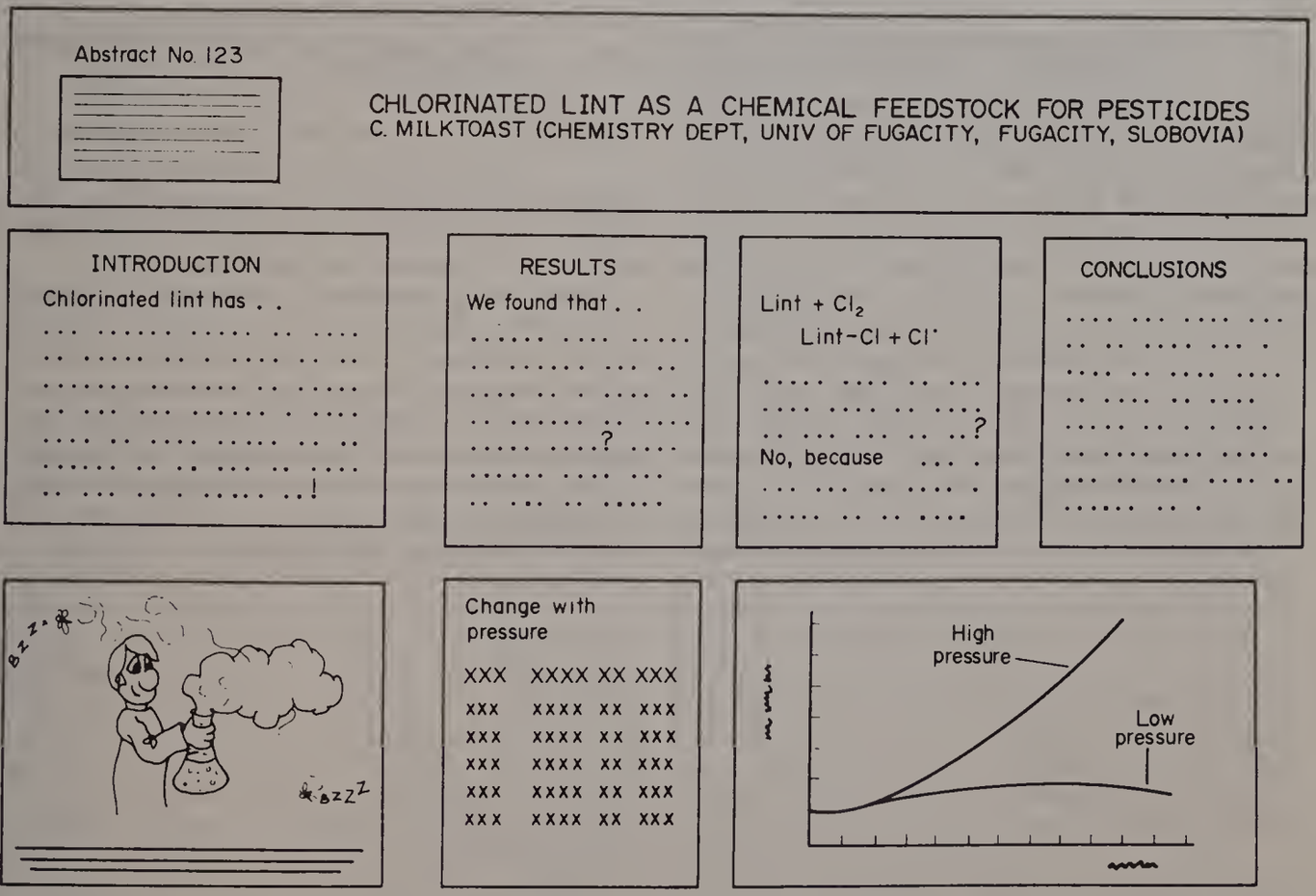

EFFECT OF ADDITIVE C
PRODUCT YIELD, VOL. %
ADDITIVE C, WT. %
EQUATION
OLD DATA
NEW DATA
USE LARGE LETTERS FOR TITLE
LIGHT LINES FOR GRID HEAVY LINES FOR CURVE
MIMIMUM NUMBER OF GRID LINES
ORIGINAL HEIGHT OF LETTERS AND FIGURES 6MM
CAPITAL LETTERS PREFERRED

III. DISPLAY (POSTERS)

Poster sessions have been gaining wide acceptance for communicating information and engendering discussion at conferences, providing a viable alternative to formal short talks. They provide much more opportunity for casual discussion and for authors to try original presentation methods. Authors can exhibit samples of key substances, data, published papers, photographs of their apparatus, of field experiments, or even of themselves. It is important to recognize that poster sessions are *not* relegated for communicating second-rate research, but allow research interests to be discussed individually or in small groups.

Most of the charts, drawings and illustrations used in a poster display might be very similar to those which would be used to make slides—although they are generally cruder and are drawn with heavier lines. Illustrations need not—in fact, should not—be "arty". Keep illustrative material simple. Simple use of colour can add emphasis effectively. Diagrams should not be drawn on heavy board, as these may be difficult to mount on poster boards. You might find it useful to have on hand a tablet of sketch paper and one or two felt marking pens.

What may be included in a poster display is limited only by the imagination of the author (within the confines of the available space). Most authors begin by preparing a label containing title, names of authors and abstract number so that the display may be easily identified (a label may be provided by the conference organizers). The label might also indicate times when the authors will be available for discussion of the posters. A copy of the abstract is often displayed. Labels and illustrations are mounted on the fibreboard, generally with thumbtacks. If you need tape, it may be necessary to provide your own. It will be worthwhile to have available all applicable figures, tables and equations, even if you do not plan to display them. Posters should be prepared by the authors in advance, and should be mounted and later removed within the time periods set aside by the conference organizers. Most conferences have "poster



A poster display should briefly explain the importance of the project, essential background information, results and conclusions reached by the authors. It should be self-explanatory on its own, although the author should be prepared to present additional data and discuss his procedure. The poster should be laid out neatly, with large print for easy viewing. At a 3-metre distance of a passing viewer, the display might look something like this.

assistants" to answer questions and help with technical problems.

Poster displays should generally be prepared so that they would be intelligible in themselves, even in the absence of the authors and without a study of the abstract. The contents of a poster may be divided into a SUMMARY (or abstract), INTRODUCTION, RESULTS and DISCUSSION. The SUMMARY should list pertinent results and conclusions. The INTRODUCTION can provide background information and state the purpose of the study in relation to previous work in this field. The RESULTS section may be divided into sub-headings, each indicating the most important finding. In general, as *few* results as possible should be included, just those necessary to validate the conclusions. A poster overloaded with findings will rarely attract attention. Indeed, there is no obligation to fill the entire available space with information! Finally, the DISCUSSION section should interpret the results and present their significance, even if speculative—summarizing the conclusions in an easily-remembered "take-home" form.

It is important to plan carefully the optimal utilization of the poster space. Subdivision into standard-size sections (for example, 9 sections 40 cm high 60 cm wide) might be helpful. Posters should be readable from a distance of 2 - 3 metres. Graphs and tables should have a minimum height of 20 cm.

A recommended size for labelling of figures and tables and the keyword text is 1 - 1.5 cm-high lettering. Smaller type than this, and lines thinner than 2 mm, cannot be easily seen from a distance. Ordinary-size typewritten material should never be used.

Tables and figures should be given a brief title. In a table, it is best to restrict oneself to four columns, with not more than four listings per column. Graphs should show a maximum of 3 curves. Drawing each curve in a different colour makes each distinctive, and is especially helpful if the curves cross or are close together. Graph axes should be clearly labelled and not overburdened with information. Thus, if an axis shows a range of 0 - 10 units, it is sufficient to label 0, 5 and 10. it is best to avoid too many digits as well, and it is preferable to label a graph axis with 0.5 and 1.0 Units, rather than 500 and 1000 milliunits.

The space below a table or figure can contain a *brief* text describing the pertinent conclusion drawn from the experimental results shown. This caption may also guide the viewer to the next experiment. Authors should be prepared to discuss experimental details when requested by an interested viewer, but this information should not be included in the poster caption, as is customary in published papers.

A more useful procedure is to prepare the poster display before setting off to the conference and to mount the display in your own laboratory, where it may be viewed and discussed by your colleagues, and possibly improved. While poster sessions do offer an informal environment for discussion of research projects, most viewers do not really enjoy the feeling of spontaneity that comes from an author who is seeing his poster for the first time.

A checklist for poster authors

SUMMARY
Is it concise enough to draw attention?

INTRODUCTION
Does it provide enough background to understand the purpose of the study?

RESULTS
Are there so many that the main contribution is obscured?
Does the keyword text between tables and figures serve as a good explanatory link?

DISCUSSION
Is the "take-home" format catchy enough to stimulate discussion?

TECHNOLOGY

Lettering:	Is size large enough for headings, tables, figures and keyword text?
Tables:	Does each have a brief title?
	Are there not more than 16 items?
Figures:	Does each have a Brief title?
	Are there not more than 3 curves on each graph?
	Are graph lines easily distinguishable?
	Does each graph line have a label which describes it?
	Are axes not overburdened with information?

The man who hoped that science could lead where diplomacy would falter

Within the last few centuries, the notion has developed that the practice of science transcends short-term commercial gains and national interests. This concept was a natural outcome of several hundred years of continuous scientific progress, in which advances in science ultimately and irreversibly affected—and largely benefitted—all mankind. The impact of scientific discoveries often extended far beyond, and was completely different from, the applications initially foreseen. Scientists did not devote their lives to their company or their country, it was said, but to *science*.

In the twentieth century, this belief has been eroded by wars: wars which could be fought on an increasing scale of devastation because of the growing scientific and technological sophistication of weapons. World Wars were new phenomena. They stemmed—like all wars—from social, political and economic causes, but they were made possible by an increased technological capability. Chemical explosives and poison gases were used on a massive scale never imagined before.

There were still those who believed that the responsibility of scientists transcended national boundaries. They fought to channel the advance of science towards constructive goals, and sought to make the benefits of science available to all. One of these men was William Albert Noyes Jr., who died recently at the age of 82.

In his own country, the United States, Dr. Noyes was well-known and respected for his work as a chemical researcher and educator, and for his involvement in advancing the profession of chemistry. He had been a member of the American Chemical Society for 60 years, during which he served a term as President. For twelve years, he was Editor of the *Journal of the American Chemical Society,* and following that, Editor of the *Journal of Physical Chemistry.* Perhaps his greatest contribution, however, was his effort to promote international scientific cooperation. His involvement in IUPAC spanned 40 years, and culminated in his Vice-presidency in 1947 - 1951, membership of the IUPAC Executive Committee in 1955 - 1959, and Presidency in 1959 - 1963.

Dr. Noyes was introduced to IUPAC through his father, Dr. William Noyes senior, an eminent organic chemist who shared his dedication to chemistry and commitment to international cooperation. W. Albert Noyes Jr. accompanied his father to a meeting in Paris of the IUPAC Commission on Organic Nomenclature in 1923. Letters sent at the time by members of this Commission, filed in the IUPAC archives, show that Dr. Noyes senior played a key role in restoring communication among chemists in Europe and North America, and that he campaigned to resume the scientific cooperation which had been terminated during and after the first World War.

In the years following World War I, Germany was excluded from participation in international political and scientific affairs. Dr. Noyes Jr. and his father were concerned with the isolation of German chemists, and felt that their participation in IUPAC was the first necessary step towards overcoming the alienation that had developed.

Immediately after his discharge from the US Army in 1919, Dr. Noyes Jr. travelled to Paris to begin research with Professor le Chatelier. While studying for his doctoral degree at the University of Paris and University of Geneva, he met Sabine, who was to be

his wife and confidant for the remaining 60 years of his life.

Dr. Noyes, his wife and father were all in Paris in March 1924, by which time it was becoming apparent that resolution of political differences was essential if future conflicts were to be avoided. Both men had virtually identical views, recalls Mrs. Noyes, who heard them talk often about international relations among scientists. At that time, Dr. Noyes senior had written to other Commission members that "unless I entirely misread the signs of the times, a solution will be found which must lead to cooperation between France and Germany and the rest of the world. We scientific men have done so much to make war horrible that it seems to me that it is our duty to *lead* in ways of peace and not merely follow in the wake of financiers and politicians."

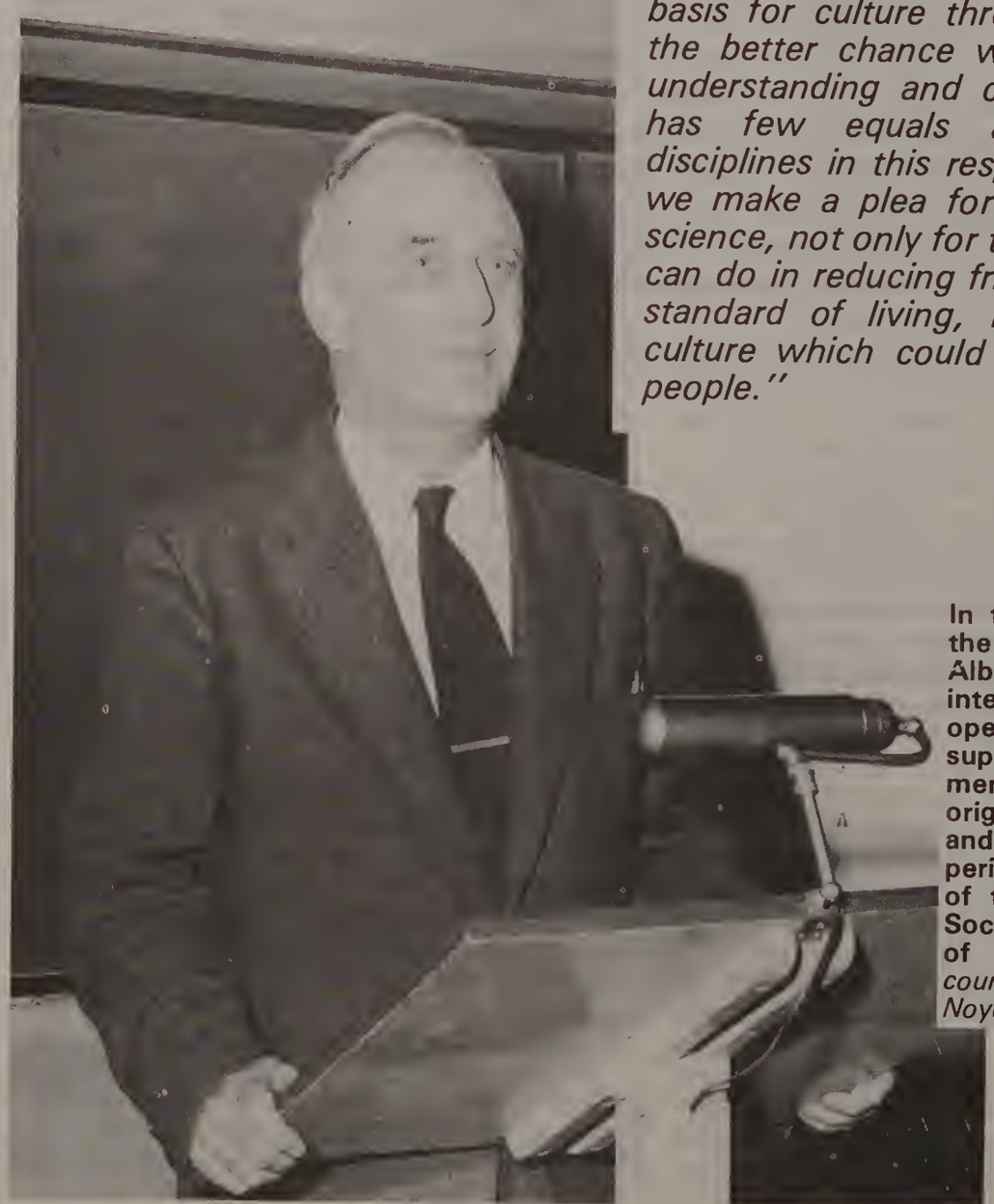
Efforts by W. Albert Noyes Jr., his father and other men failed to interrupt the chain of events leading to the outbreak of the second World War. Yet, they persisted in their efforts. Immediately after that war, Albert Noyes Jr. participated in drafting the original plans for UNESCO, and was among the first United States delegates at UNESCO's inaugural meeting in 1949. He served as a member of the US Commission to UNESCO for six years.

In his article *International Aspects of Science* (published in Transactions of the New York Academy of Sciences, January 1948), Dr. Noyes wrote, "Science has become a matter of political as well as economic and social importance, due to the fact that it is essential for modern war. Scientists themselves have not fully recognized the important position that they occupy in the world today, although a minority realize that they have contributed to making war more awful and, through a sense of guilt, have come to believe that it is high time they took a greater interest in the cause of peace."

"There are more chemists in the United States than in all the Western Europe . . . We often feel that it is more convenient, as well as more efficient, to carry on by ourselves than it is to elicit the cooperation and support of other nations. All too often we forget that actions which appear to us to be for the good of science appear to others to be selfishly nationalistic."

"The organizations (for international cooperation) established after the close of World War I were ineffective largely because they were innocuous. They made scholarly studies in many important domains, but through lack of funds and perhaps,

"The more we can provide a common basis for culture throughout the world, the better chance we have for mutual understanding and confidence. Science has few equals among the other disciplines in this respect . . Therefore, we make a plea for internationalism in science, not only for the material things it can do in reducing friction by raising the standard of living, but in providing a culture which could be common to all people."



In the period directly after the second World War, W. Albert Noyes Jr. promoted international scientific co-operation as a platform to support peaceful development. He helped draft the original plans for UNESCO, and during the same time period, served as President of the American Chemical Society and Vice-President of IUPAC *(photograph courtesy of Mrs. Sabine Noyes).*

also, through fear of intruding in national fields, they did not become operating organizations. There is a similar tendency evident in the thinking of many persons about UNESCO. The problems of the Science Division are relatively concrete, and there seems to be fairly general agreement that UNESCO must do more than make harmless studies."

"The more we can provide a common basis for culture throughout the world, the better chance we have for mutual understanding and confidence. Science has few equals among the other disciplines in this respect except for one difficulty—the small number of persons who really understand it. Therefore, we make a plea for internationalism in science, not only for the material things it can do in reducing friction by raising the standard of living, but in providing a culture which could be common to all people."

That culture and scientific training, he emphasized, should be widely available to the people of all countries. "For every scientist with new and brilliant ideas, scores of . . scientifically trained men are essential to do the everyday work and to put new ideas into practice. One Nobel Prize winner, in other words, does not make a country strong. Hence, an important thing for UNESCO or for any other international scientific organization to do, is to broaden the base of education so that each country will be adequately supplied not only with pure scientists, but with applied scientists and engineers."

Fifteen years later, in an article *Foreign Policy and Scientists* (published in The Chemist, February and March 1963), Dr. Noyes projected that those trained in science would become a much larger and politically influential group. The demand for better health and a higher standard of living in developing countries would, he argued, encourage a major expansion of scientific training and research outside the United States and Western Europe. He estimated that about the middle of the 21st century, there would be at least 30 million scientists and engineers throughout the world, comprising as much as 1% of the global population.

He directed his discussion specifically to the training of scientists in developing countries. "As these countries gain independence", he wrote, "they must have some leaders, some professional men, many teachers. If these persons are not already on hand and local institutions do not exist for training them, they must be trained abroad. However, conditions must be created as rapidly as possible to make these foreign trained students happy to return to their native lands. All too often, students are exchanged without any thought of providing laboratories, libraries, and equipment for them to use when they return."

In 1963, W. Albert Noyes left his post at the University of Rochester (New York, USA), where he had become Chairman of the Chemistry Department and Dean of the Graduate School, accepting a chair at the University of Texas. There, he taught general and physical chemistry and presented courses with a philosophical view of science. His course "Science in Government and in International Affairs" was one of the most popular courses at the University of Texas.

Above all else, W. Albert Noyes Jr. was a chemist. He had studied electrochemistry (at the University of Paris) and electrical phenomena in gas discharges (at the University of California), but he chose photochemistry as his field of research, having been inspired by lectures of Madame Curie and Jean Perrin while a student in Paris. Dr. Noyes authored or co-authored well over 200 research papers during his career, and co-authored "Photochemistry of Gases", the first recognized textbook in this field.

Even after his formal retirement in 1973, Dr. Noyes visited his laboratory daily and actively participated in chemistry department activities at the University of Texas. Despite a visual impairment that prevented him from reading journals during the last few years, he kept abreast of recent chemical developments. His wife Sabine read articles to him on many occasions.

Among the many honors that have been bestowed on Dr. Noyes during his distinguished career are the King's Medal for "Service in the Cause of Freedom" (U.K.) in 1948; membership in the US and French National Academies of Science; honorary memberships in the chemical societies of France, Belgium, Spain and Portugal; the Priestly and Willard Gibbs Medals and Charles L. Parson Award of the American Chemical Society, and nine honorary doctorate degrees.

Chemical concepts are tested on new man-made elements

The possible existence of stable superheavy elements, with atomic numbers greater than 110, has long been suspected. Recent experimental and theortical results reported at the IUPAC-sponsored International Symposium on the Synthesis and Properties of New Elements reinforced this prediction, conference organizer Yu. Ts Oganessian reported to *Chemistry International.* He sensed a growing confidence that superheavy elements with enhanced stability will be found at major nuclear physics centres at JINR (Dubna, USSR), GSI (Darmstadt, Federal Republic of Germany), the University of Mainz and Marburg (Federal Republic of Germany) and at the Lawrence Livermore Laboratories (California, USA). Prof. Oganessian did not, however, overlook the difficult experimental problems confronting nuclear researchers.

The first attempts to produce elements with atomic numbers greater than 92 were made by bombarding uranium with neutrons. In recent years, heavy ion physics has increasingly been applied to the synthesis of new transuranium elements. Fusion reactions, in-

duced by bombarding very heavy target nuclei, now appears the most promising route for making superheavy elements. Synthesis of new elements in this way requires the generation of intense beams of heavy ions such as ^{48}Ca or ^{238}U, targets of man-made metals such as ^{244}Pu, ^{248}Cm, ^{249}Cf, and extremly rapid and sensitive experimental techniques. Some particle accelerators can now produce high-energy heavy ion beams with an intensity of 10^{13} particles/second, allowing experimental sensitivity to be increased a hundred-fold.

Chemical properties of heavy actinide elements and new transactinide elements have recently come under study, offering the opportunity to test and develop a number of theoretical and model concepts in chemistry, Here too, new techniques able to cope with intractable experimental problems were reported at the conference (held September 1980 in Dubna, USSR). Most superheavy elements have a very short life time before they emit radiation and decay to lighter, more stable nuclei. To investigate the chemical properties of these elements, new compounds must be synthesized, purified and studied before the element decomposes.

The rapid separation of chemical compounds by gas thermochromatography is one very promising experimental technique. This method was applied by French researchers to study the decomposition temperature of fluorides of the actinide elements Pu, Am, Cm, Bk, Cf and Es. Their results, explained Prof. F. David, (at the Institute of Nuclear Physics in Orsay), provides the first experimental indication of the existence of a tetravalent einsteinium compound, EsF_4. Furthermore, preliminary measurement of diffusion coefficients show that einsteinium and californium have different ionic radii than would have been expected.

The same research team also described their studies of mendelevium, the heaviest actinide with a comparatively long-lived isotope. They measured its electrochemical reduction potential in aqueous solution and how electrochemical properties were affected by complexing with citrate, acetate and chloride ions. The chemical behaviour of mendelevium was found to be very similar to that of divalent fermium.

Dr. David's discussion of the chemical properties of actinides, and six other plenary lectures presented at the conference, will be published in the May 1981 issue (No. 5) of *Pure & Applied Chemistry.*

Better data gives more insight into metabolism of living cells

Metabolic activity of living cells can be monitored by measuring their heat evolution in a microcalorimeter. Such calorimetric data may be used, for example, to characterize microorganisms or monitor differences in cell metabolism of patients and healthy individuals (for example, one human red blood cell normally generates about 8×10^{-15} watts of heat, corresponding to about 80×10^{-6} watt per cm^3 of packed cells). However, most researchers who perform biothermodynamics experiments do not realize that their data can have significant thermodynamic value—provided that measurements are properly controlled and results are correctly described. Without an adequate description of experimental procedures, it is difficult for other groups to interpret or reproduce biothermodynamics measurements. Not all experimenters report initial and final pH values or oxygen concentrations during calorimetric measurements. Experimental results also depend upon whether cells remain suspended in solution, or adhere to the walls of the calorimeter vessel.

The Interunion Commission on Biothermodynamics, whose members represent the three international scientific unions dealing with chemistry (IUPAC), biochemistry (IUB) and biophysics (IUPAB), believes that calorimetric data on cellular systems could have greater usefulness if improved measuring and reporting procedures are adopted. Their report, *Calorimetric measurements on cellular systems: recommendations for measurements and presentation of results* (to be published in *Pure & Applied Chemistry* later this year), advocates the use of sound experimental procedures. It also urges experimenters to specify all pertinent experimental details when reporting their results. The report discourages the use of arbitrary units like "mm recorder deflection" to indicate heat evolution. The same results, the report argues, could have general and lasting value if the calorimeter is properly calibrated. Microcalorimeters can usually be calibrated by using an electrical heater to closely simulate heat evolution by biological organisms. In other cases, it may be preferable to use a chemical reaction to calibrate the calorimeter.

Free booklet lists current IUPAC projects and recent reports

Projects now being undertaken by IUPAC's Commissions and Committees have been compiled into a comprehensive listing, contained in a booklet which is available free-of-charge from the IUPAC Secretariat. The booklet provides the title of each project, the individual who coordinates it, the starting date of the project, and expected date of completion or review. An innovation in this new edition of the *Current IUPAC Programmes* booklet is the inclusion of an Appendix, which lists all reports published by IUPAC Commissions and Committees during the period 1974 - 1980. To obtain your copy of the booklet, write to Mr. P.D. Gujral, IUPAC Secretariat, 2 - 3 Pound Way, Cowley Centre, Oxford OX4 3YF, UK.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1981

SURFACE AND COLLOID SCIENCE
July 5 - 10. 4th Int'l Conference on Surface and Colloid Science. Jerusalem, Israel.
(Prof. A. S. Kertes, Institute of Chemistry, The Hebrew University, Jerusalem, Israel.)

MACROMOLECULAR CHEMISTRY
July 6 - 9. 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire Tour 44, 1er Etage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cédex 05, France.)

MÖSSBAUER EFFECT
July 13 - 17. Int. Conference on the Application of the Mössbauer Effect. Srinagar, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi, 110012, India.)

POLYMER CHARACTERIZATION
July 13 - 17. Int'l Symposium on Advances in Polymer Characterization. Durham, UK.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK.)

CHARACTERIZATION OF POLYMERS BY NMR
July 20 - 23. 22nd Prague Microsymposium on Characterization of Dynamic and Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlácek, Institute of Macromolecular Chemistry Czechoslovak Academy of Sciences, Heyrovského n.2, CS-162 06 Praha 616, Czechoslovakia.)

CAROTENOIDS
July 26 - 31. 6th Int'l Symposium on Carotenoids. Liverpool, UK.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, POB 147, Liverpool L69 3BX, UK.)

ORGANOMETALLIC CHEMISTRY
August 2 - 6. Int'l Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, USA
(Dr. L. S. Hegedus, Dept. of Chemistry, Colorado State University, Fort Collins, Colorado 80523, USA.)

CHEMICAL EDUCATION
August 9 - 14. 6th Int. Conference on Chemical Education. Maryland, USA.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington DC 20550, USA.)

ORGANOMETALLIC CHEMISTRY
August 9 - 14. 10th Int'l Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1.)

PLASMA CHEMISTRY
August 10 - 14. 5th Int'l. Symposium on Plasma Chemistry. Edinburgh, UK.
(Dr. B. Waldie, Chairman, Department of Chemical and Process Engineering, Heriot-Watt University, Chambers Street, Edinburgh EH1 1HX, UK.)

IUPAC CONGRESS
August 16 - 22. 28th IUPAC Congress. Topics are: Chemistry applied to energy problems, environment upgrading of resources, computers, analytical chemistry, physical chemistry, inorganic chemistry, organic chemistry. Vancouver, Canada.
(IUPAC Congress Secretariat, c/o Chemical Institute of Canada , 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada.)

ANALYTICAL STUDIES
August 20 - 21. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford Street, London SE1 9NQ UK.)

HETEROCYCLIC CONGRESS
August 23 - 28. 8th International Congress of Heterocyclic Chemistry. Graz, Austria.
(Prof. Dr. Thomas Kappe, Institute of Organic Chemistry, University of Graz, Heinrichstr. 28, A-8010 Graz, Austria.)

ORGANOSILICON
August 23 - 29. 6th Int. Symposium on Organosilicon Chemistry. Budapest, Hungary.
(Prof. Tomás Székely, Chairman of the Organizing Committee, Research Laboratory for Inorganic Chemistry of the Hungarian Academy of Sciences, H-1502 Budapest, Pf. 132. Hungary.)

DRUG RESEARCH
August 25 - 28. Int. Symposium on Strategy in Drug Research. Noordwijkerhout, The Netherlands.
(Symposium Secretary, Dr. M. L. de Winter, Philips Duphar B.V. POB 2, 1380 AA Weesp, The Netherlands.)

IUPAC GENERAL ASSEMBLY
August 25 - September 2. 31st IUPAC General Assembly. Leuven, Belgium.
(IUPAC Secretariat, 2-3 Pound Way, Cowley Centre, Oxford, 0X4 3YF, UK.)

AROMATIC COMPOUNDS

August 30 - September 4. 4th Int'l Symposium on Chemistry of Novel Aromatic Compounds. Jerusalem, Israel.
(Prof. I. Agranat, Dept. of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel.)

ATOMIC SPECTROSCOPY

September 4 - 8. 9th International Conference on Atomic Spectroscopy and 22nd Colloquium Spectroscopicum Internationale. Tokyo, Japan.
(The Japan Society for Analytical Chemistry, 9th ICAS/ 22nd CSI, Gotanda Sanhaitsu, 26-2 Nishigotanda 1-chome, Shinagawa-ku, Tokyo 141, Japan.)

MATERIALS AT HIGH TEMPERATURES

September 7 - 10. The Chemistry of Materials at High Temperatures. A.E.R.E. Harwell, Oxford, UK.
(Dr. P. E. Potter, Chemistry Division, A.E.R.E. Harwell, Didcot, Oxon OX11 ORA, UK.)

BIO-CALORIMETRY

September/October. International Symposium on Bio-Calorimetry Tibilisi, Georgian SSR, USSR.
(Dr. P. G. Asatiani, Institute of Physics, Acad. Sci. GSSR, Guramishvili str. 6, 380077 Tbilisi, USSR.)

CHEMICAL PHYSICS

September 28 - October 4. Int'l Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2 - 6, SU-117334 Moscow, USSR.)

1982

CHEMISTRY RELATING TO AGRICULTURE

February 2 - 5. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN 11) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington D.C. 20036, USA.)

SAFE USE OF SOLVENTS

March 23 - 27. International Symposium on the Safe Use of Solvents. Brighton, UK.
(Mr. S. G. Luxon, Health & Safety Executive, 25 Chapel Street, London NW1 4DT, UK.)

CLINICAL CHEMISTRY

April 19 - 22. International Congress on Automation in Clinical Laboratory. Barcelona, Spain.
(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clinicos, C.S. "Principes de Espana", Hospitalet de Llobregat, Barcelona, Spain.)

PHYSICAL ORGANIC CHEMISTRY

July 11 - 16. 6th IUPAC Conf. on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, 1348 Louvain-la-Neuve, Belgium.)

MACROMOLECULES

July 12 - 16. IUPAC Macromolecular Symposium. Amherst/Ma. USA.
(James C. W. Chien, Dept. of Polymer Science & Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA.)

SELECTIVE POLYMER SORBENTS

July 19 - 22 23rd. Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia
(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 162 06 Prague 616, Czechoslovakia.)

POLYMERIZATION OF HETEROCYCLES

Summer. Int'l Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.
(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, POB 49, Curie-Skodowskiej 34, PL-41 800 Zabrze, Poland.)

NATURAL PRODUCTS

August 2 - 7. 13th Int. Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs. Jeanne Beck, Symposium Secretariat - S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa.)

ORGANIC SYNTHESIS

August 22 - 27. 4th International Conference on Organic Synthesis. Tokyo, Japan.
(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.)

COORDINATION CHEMISTRY

August 23 - 27. 22nd. Int Conf. on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010, Hungary.)

PESTICIDE CHEMISTRY

August 29 - September 4. 5th Int. Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan.)

MYCOTOXINS AND PHYCOTOXINS

August 31 - September 2. 5th. Int. IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Head, Department of Microbiology Royal Dental College, Juliane Mariesvej 302, DK-2100 Copenhagen 0, Denmark.)

THEORETICAL CHEMISTRY

September. International Symposium on Theoretical Organic Chemistry. Dubrovnik, Croatia, Yugoslavia.
(Dr. Ante Graovac, Institute "R. Bosković", POB 1016, 41001 Zagreb, Yugoslavia.)

1983

IUPAC GENERAL ASSEMBLY

August 18 - 26. 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.
(IUPAC Secretariat, 2-3, Pound Way, Cowley Centre,Oxford OX4 3YF, UK.)

1984

BIOTECHNOLOGY

November/December. 7th Int. Biotechnology Symposium. New Delhi, India.
(Prof. T. K. Ghose, Chairman, National Organisation Committee & Head, Biochemical Engineering Research Centre, Indian Institute of Technology, Hauz Khas, New Delhi-110029, India.)

Chemistry International

is the news magazine of the

INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY (IUPAC)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

NATIONAL MEMBER ORGANIZATIONS

Academy of Scientific Research and Technology **(Arab Republic of Egypt)**
Asociación Química Argentina **(Argentina)**
Australian Academy of Science **(Australia)**
Verein Österreichischer Chemiker **(Austria)**
Comité National Belge de Chimie **(Belgium)**
Associação Brasileira de Química **(Brazil)**
Bulgarian Academy of Sciences **(Bulgaria)**
National Research Council of Canada **(Canada)**
Chinese Chemical Society, and Chemical Society located in Taipei, China **(China)**
Ministerio de Minas y Petróleos **(Colombia)**
Academia de Ciencias de la República de Cuba **(Cuba)**
Czechoslovak National Committee of Chemistry **(Czechoslovakia)**
Det Kongelige Danske Videnskabernes Selskab **(Denmark)**
Suomen Kemian Seura **(Finland)**
Comité National Français de la Chimie **(France)**
Deutscher Zentralausschuss für Chemie **(Federal Republic of Germany)**
Akademie der Wissenschaften der DDR **(German Democratic Republic)**
Association of Greek Chemists **(Greece)**
Hungarian Academy of Sciences **(Hungary)**
Indian National Science Academy **(India)**
Iraqi Chemical Society **(Iraq)**
Royal Irish Academy **(Ireland)**
Israel Academy of Sciences and Humanities **(Israel)**
Consiglio Nazionale delle Ricerche **(Italy)**
Science Council of Japan **(Japan)**
Koninklijke Nederlandse Chemische Vereniging **(Netherlands)**
Royal Sociey of New Zealand **(New Zealand)**
Norsk Kjemisk Selskap **(Norway)**
Polska Akademia Nauk **(Poland)**
Sociedade Portuguesa de Química **(Portugal)**
Korean Chemical Society **(Republic of Korea)**
Council for Scientific and Industrial Research **(Republic of South Africa)**
Academia Republicii Socialiste România **(Romania)**
Consejo Superior de Investigaciones Científicas **(Spain)**
Svenska Nationalkommittén för Kemi **(Sweden)**
Schweizerisches Komitee für Chemie **(Switzerland)**
Supreme Council of Sciences **(Syrian Arab Republic)**
Türkiye Kimya Dearneği **(Turkey)**
Academy of Sciences of USSR **(USSR)**
Royal Society **(United Kingdom)**
National Research Council, National Academy of Sciences **(USA)**
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Chemistry International

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OUR MAN GOES TO SOUTHEAST ASIA TO FILE THIS ISSUE'S SPECIAL REPORT.

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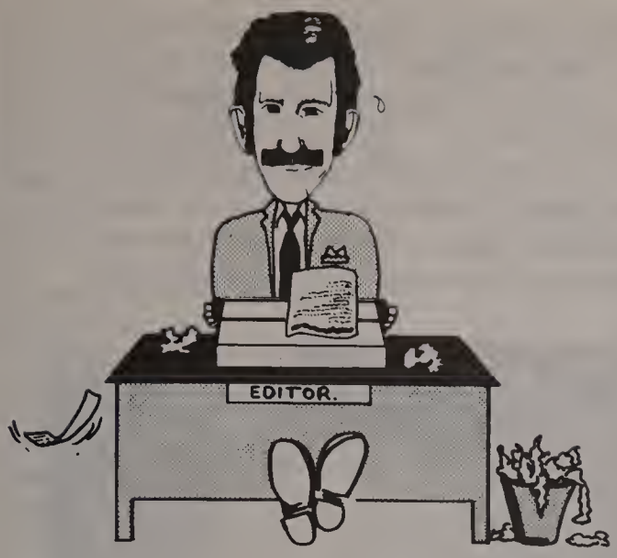

THE EDITOR'S DESK

Opinions expressed here are those of the author, and do not necessarily reflect the views or policy of IUPAC.

Prevention of cancer is linked to vitamin C

It is very unusual to attend a lecture at a chemistry conference at which one is literally stunned by its sweeping significance. It happened to me recently—for the first time—when I heard Prof. Linus Pauling speak at the First Asian & Pacific Chemistry congress (held in Singapore on April 27 - May 1). I already knew that Prof. Pauling had written a popular book, "Vitamin C and the Common Cold", in which he presented evidence that large daily doses of vitamin C can reduce the incidence and severity of the common cold. Yet, I was totally unprepared for his assertion that vitamin C can effectively treat or prevent cancer, hepatitis and a range of other diseases. For those who hadn't heard the lecture, it would be tempting to dismiss these conclusions as premature, exaggerated or a hoax. Indeed, the conclusions are based on preliminary studies, but the evidence cited by Prof. Pauling was compelling, his explanations plausible, and his competence beyond reproach (confirmed by conferral of the Nobel Prize in Chemistry in 1954, the Nobel Peace Prize in 1962, and other coveted awards).

Prof. Pauling recounted his experiences, as far back as 25 years ago, which were to lead him into the area which he now terms "orthomolecular medicine". He had been involved in medicinal chemistry for many years (for his pioneering work in determining the cause of sickle cell anaemia, he was later to receive the first Dr. Martin Luther King Jr. Medical Achievement Award), and was thus aware of Canadian research performed in 1954 which demonstrated that patients suffering from schizophrenia benefited from massive doses of niacin (nicotinamide). It had been well-known for many years that this B vitamin was essential for the prevention of pellegra, (a disease characterized by skin lesions diarrhoea and mental disorders). Five milligrams of niacin per day was found to be just sufficient to prevent pellagra, and the US government established 17 mg as the "Recommended Daily Allowance". However, for the treatment of schizophrenic patients, the Canadian researchers were administering 50 000 mg/day, and sometimes as much as 250 grams per day. Prof. Pauling was struck that these dosages were *10 000 - 50 000 times greater* than the amount necessary to prevent disease, but did no apparent harm to the patients. By contrast, most drugs are fatal at five or ten times the normal clinical dose (the dose necessary to exert the desired effect).

This led Prof. Pauling to consider the possibility that other diseases could be treated with large doses of vitamins, or other compounds normally present in the human body at low concentration. He was eventually to investigate the role of vitamin C in preventing colds. In retrospect, it is perhaps amazing that medical researchers had not focussed attention on this simple compound, ascorbic acid.

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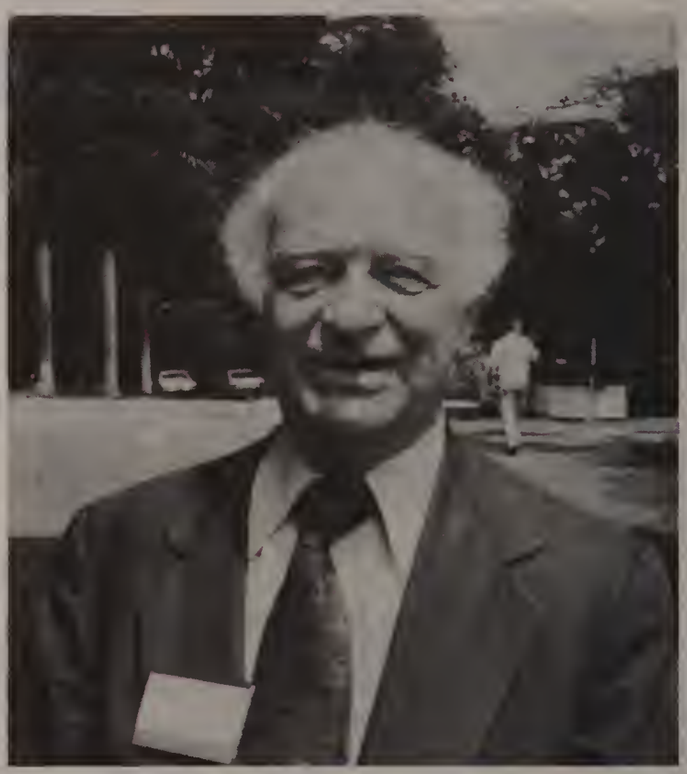
Vitamin C research had essentially ended 200 years ago, when it was discovered that small amounts of ascorbic acid were necessary to prevent scurvy. This disease had been endemic among sailors, who were deprived of fresh fruit and vegetables while on long sea voyages. Without an intake of vitamin C, the body is unable to synthesize collagen, the macromolecule which forms cartilage and tendons and holds body cells together. By administering lime juice to sailors, scurvy was virtually eliminated. Fifty milligrams of ascorbic acid was discovered to be more than adequate to prevent scurvy, and this was later established by most governments as the "Recommended Daily Allowance".

But, is the amount of ascorbic acid necessary to prevent disease, the optimal amount for good health? Prof. Pauling presented convincing arguments that it is not. Human beings are one of the very few animal species which cannot synthesize the ascorbic acid they need. This ability has been lost during human evolution, Prof. Pauling argues, because this capability was not needed by our ancestors living in tropical forests. They had access to large amounts of citrus fruits, and their diet might have contained as much as 10 grams/day of ascorbic acid (200 times the present "Recommended Daily Allowance"). In this environment, the ability of humans to synthesize vitamin C would have been redundant, and would gradually be lost by natural selection of other characteristics which were necessary for survival.

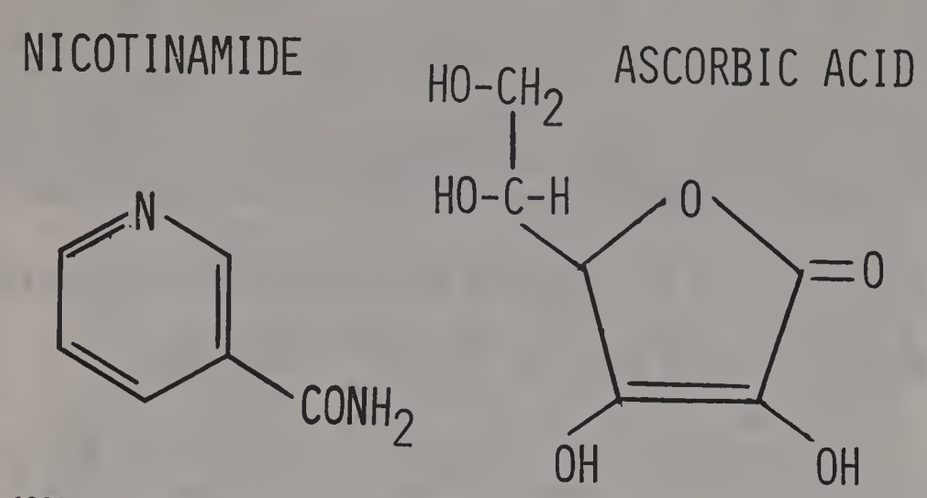


Prof. Linus Pauling relaxes during a coffee break at the 1st Asian & Pacific Chemistry Congress.

Other animal species synthesize vitamin C at a rate of 2 - 20 grams/day (for a body weight equivalent to that of an adult human, about 70 kg). "*This* is the amount of vitamin C made each day by a 70 kg goat", Prof. Pauling stated during his lecture, holding up a test tube two-thirds full (with 13 grams) of vitamin C. "*This* is the amount made each day by a human being", he said, holding up an empty test tube ... "and *this* is the amount recommended for our daily intake", he stated, holding a test tube with a few grains (50 mg) of vitamin C.

The rate at which animals synthesize vitamin C is not constant. A rat, which normally produces 4 grams/day of vitamin C, increases its synthesis of ascorbic acid when wounded or placed under stress. In the same way, Prof. Pauling feels that humans require increased amounts of vitamin C when their defense system is under attack by disease or emotional stress. This is not a new idea. Some 50 years ago, it was recommended that surgeons administer vitamin C to patients recovering from wounds or surgery.

Cancer is one type of disease which seems to be caused, in part, by inadequacy of the body's defense system. One cancer specialist, Dr. Ewan Cameron, became interested in the possibility of administering large doses of vitamin C to terminally-ill cancer patients after he had read about Prof. Pauling's work. These patients did not respond to available chemotherapy drugs. The number of surviving patients declined exponentially with the time that the disease had progressed. Only 0.3% survived for more than 400 days. Dr. Cameron did not initially believe that such a common, cheap and readily-available compound as ascorbic acid could be effective in treating these cancers. Nonetheless, because of the suggestion that very sick people might benefit from large doses of vitamin C, and because ascorbic acid had no clear toxic effects—even in massive doses, Dr. Cameron decided to administer large doses of vitamin C to his terminally-ill cancer patients. Prof. Pauling suggested



Nicotinamide (vitamin B_3) and Ascorbic Acid (vitamin C) are distinctly different from other medicinal compounds presently used to treat disease. Conventional drugs exert their biological activity over a narrow range of concentration. Even commonly-used drugs, like aspirin for example, can be fatal at only ten times the normal dose. On the other hand, nicotinamide and ascorbic acid (whose structures are shown above) show no toxic effects at 1000 or more times the dose necessary to prevent the onset of pellagra or scurvy.

a daily dose of 10 grams/day, although as much as 75 grams/day were given to some patients (and there is some evidence that these larger doses were more effective). Dr. Cameron reported that administration of these large doses of ascorbic acid did not alter the exponential form of the life-expectancy curve, but slowed the progression of the disease by two-thirds. Among those treated with vitamin C, 16% survived more than 400 days, and many patients reported an enhanced sense of well-being. Over 500 patients have now been treated with vitamin C at the Vale of Leven Hospital (Scotland). The results have been so promising that nearly all cancer patients at this hospital now receive vitamin C, as do many cancer patients of other doctors in neighboring regions. Some physicians in the United States have also begun use of vitamin C with cancer patients, although the value of vitamin C in cancer therapy is not yet generally accepted by the medical profession.

Patients who are thought to be terminally ill from cancer do, very rarely, make a full recovery. It is not therefore unexpected that a few "terminally ill" patients undergoing treatment with ascorbic acid should experience a regression of the disease, or a full recovery. However, the case histories of these patients suggest a correlation between regression of the disease and intake of ascorbic acid. After his lecture, Prof. Pauling described to me one case of particular interest. The patient began to improve immediately after ascorbic acid administration was begun, and experienced what was thought to be a total regression of the disease. His recovery was so impressive that he was released from the hospital and administration of ascorbic acid discontinued. The disease recurred soon afterwards and the patient nearly died. He did, however, respond once again to massive doses of vitamin C. The disease regressed. The patient was again released from the hospital, but the daily administration of vitamin C was continued (and will, no doubt, continue indefinitely). This patient, noted Prof. Pauling, is still free of the disease, has returned to work, and has been living a normal life for the past seven years.

Prof. Pauling believes that administration of ascorbic acid could become an integral part of therapy given to the majority of cancer patients. It could augment conventional treatment by helping the body's immune system to counter toxic effects of chemotherapy drugs, as well as helping the body's defense against the disease itself.

Prevention of disease, and not cure, is the primary role that Prof. Pauling envisages for a daily intake of vitamin C, although the effectiveness of vitamin C in preventing disease can only be proven after years of testing. Prof. Pauling (who is 80 years old) and his wife have been taking 10 gram daily doses of vitamin C for the last ten years, and their vitality certainly adds credence to Prof. Pauling's proposition. However, one might equally well form the impression that winning a Nobel Prize is good for one's health. Another Nobel laureate who attended the First Asian & Pacific Chemistry Congress, 70 year-old Melvin Calvin, didn't look a day over fifty. Thus, the secret formula for good health and long life seems to be: take vitamin C (about 10 grams/day, the cheapest brand will do), don't smoke, and win at least one Nobel Prize.

Dr. Martin Gellender

Pollution is implicated as sole cause of global lead contamination

Are present levels of heavy metals distributed throughout the environment a recent and disturbing consequence of pollution, or do they merely represent a modest elevation of natural background levels? The first attempt to answer this question involved the measurement of lead levels in Greenland snow. These experiments indicated that concentrations of lead deposited in snow had risen dramatically (to more than 500 times natural background levels) since the onset of the industrial revolution. Other researchers criticised this conclusion, attributing the results to recent local contamination of the surface snow layer (see Heavy metals: the good, the bad & the ugly in *Chemistry International,* 1980, No.2). The subject has remained a contentious issue. However, conclusive new evidence announced at the 1st Asian & Pacific Chemistry Congress could finally resolve this controversy.

The evidence was collected by Dr. Barry Noller and researchers Dr. Rhys Jones and Jim Stockton (from the Department of Prehistory of the Australian National University), who comprised an interdisciplinary team studying ancient human and animal remains of Aboriginal tribes which lived on the west coast of the island of Tasmania (an Australian state between latitudes 40° and 50°S, adjacent to the Southern Ocean). During the period 6000 B. C. until about 1830 (when the aboriginal population disappeared from Tasmania), Tasmanian aboriginals collected seashells and bones of animal prey into huge garbage piles, called "middens". The recent unearthing of several such piles gave researchers a unique opportunity to measure heavy metal concentrations in bone samples originating from this pre-industrial society. Since bone is the major organ in which ingested lead is deposited, the aboriginal bone samples provided a dated record of environmental lead contamination. Information could also be derived about pre-industrial environmental cadmium levels, since this element is partially deposited in bone.

The Tasmanian bone remains are unique for two reasons. Firstly, the Tasmanian aboriginals lived in an environment totally isolated from the effects of industrialization. Metal mining, and its accompanying pollution, have been carried out in Europe for at least 4500 years, but the aboriginals had already disappeared by the time industrialization was introduced to Tasmania. Secondly, bones discarded by the aboriginals were maintained in an excellent state of preservation. The aboriginal garbage contained a preponderance of seashells, whose content of $CaCO_3$ created an alkaline environment which inhibited the leaching of heavy metals.

The research group sorted, ground and dissolved the bone samples in concentrated nitric acid. Levels of lead and cadmium were determined by analyzing the solutions in a graphite furnace atomic absorption spectrophotometer. In all the samples, lead concentrations were found to be at least 100 times less than lead concentrations in bones of present-day humans (recently reported to be 17 - 30 parts-per-million in the USA and UK). This strongly supports the view that present lead levels in the bodies of humans is due almost entirely to environmental contamination, and virtually none can be attributed to a natural background concentration of lead.

Not so for cadmium. This element was found to be present with about the same concentration (1 - 2 ppm) in aboriginal bone samples and bones of present-day animals. This result was unexpected, since cadmium contamination has recently been shown to be a significant environmental hazard resulting from mining and smelting of cadmium-containing ores. It may be that cadmium pollution is a serious—but localized—problem, while lead has now become pervasive throughout the environment (with large amounts distributed in automobile exhaust, and significant concentrations found in paints, canned food and glazed crockery). Alternately, the results might reflect the route by which cadmium is metabolized in the body. Most ingested cadmium is retained in the kidneys and liver; perhaps the sites in bone capable of binding cadmium are completely filled with very low cadmium intake. A third possible explanation is that the cadmium content of the ancient bones reflects the diet of the Tasmanian aboriginals, which was based almost entirely on shellfish and fish-eating animals (mostly seals, seabirds and the Southern Sea Elephant which is now extinct in Tasmania). It is well established that cadmium is accumulated and concentrated in the marine food chain. Perhaps even with the extremely low cadmium levels which probably existed in the pre-industrial environment, exclusive reliance on seafood created a potential vulnerability to heavy metals. In order to support or refute this explanation, further measurements are being undertaken on cadmium levels in modern seals and marine birds.

The unearthiing of an ancient aboriginal campsite and garbage dump (in West Point, Tasmania), containing animal and human bones discarded during a period spanning 500 years, provided a unique opportunity to establish heavy metal concentrations before industrialization. Individual seashells and bones are clearly visible in the close-up view. *Photographs courtesy of Dr. Rhys Jones and Mr. J. Stockton.*

Electrochemical components take a place alongside the silicon chip

Advances in the solid-state physics of germanium and silicon semiconductors provided the foundation for the microelectronics revolution. Chemistry has contributed relatively little to the advance of microelectronics, but this situation might be altered by recent developments of novel electrochemical components for use in electronic circuitry. Such electrochemical devices operate in much the same way as silicon semiconductors, except that the electrical currents are carried by ions — and not electrons or "holes".

The conduction of electricity by molten salts, arising from the free diffusion of ions in an electric field, has been well-known and commercially exploited for over a century. *Solid* electrolytes, in which ions are bound in a rigid crystalline lattice, generally do not conduct electricity (except for very small currents due to lattice defects). However, a few crystalline salts exhibit entirely different electrical properties. The first to be discovered, in 1913, was a conductive solid phase of silver iodide existing above 147^0C. The electrical conductivity of this

salt is at least a thousand times more than most other silver salts. Upon melting (at 555^{0}C.), the conductivity of silver iodide actually falls slightly.

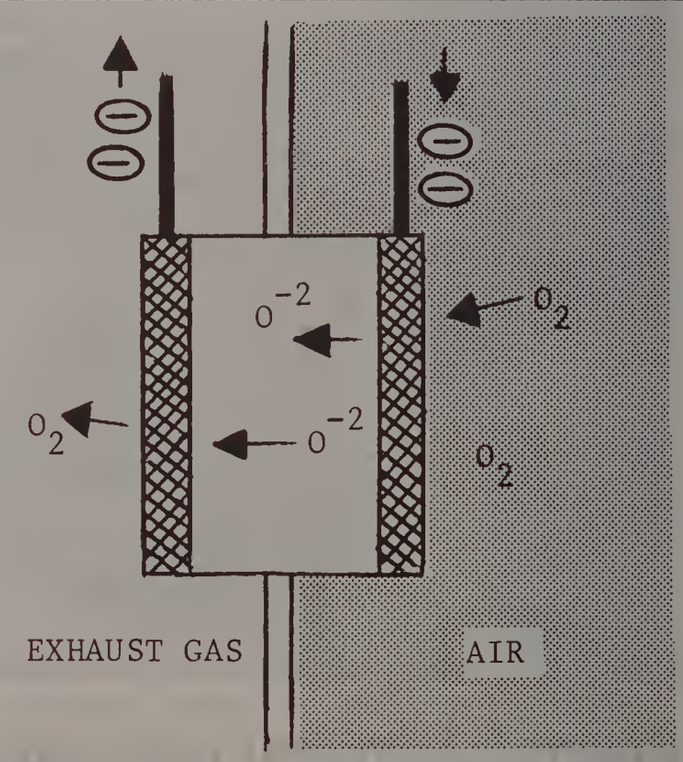
Ionic conductivity of solid salts remained a laboratory curiosity until the early 1960's, when Ag_3SI was found to exhibit high silver ion conductivity *at room temperature.* Since then, more than a dozen silver salts have been found to be "super-ionic conductors". Of these $RbAg_4I_5$ has the highest room temperature conductivity yet discovered, 0.27 $ohm^{-1}cm^{-1}$ (that is, the material would conduct a current of 0.27 amperes/cm^2 if a potential of one volt were applied across a slab one centimetre thick).

A systematic search has now begun for other ionic crystals which exhibit high ionic conductivity at room temperature. Such compounds are of considerable practical significance, as they may be utilized in solid-state batteries and new types of electronic components. To prepare stable crystalline salts which are conductive at room temperature, the AgI crystal lattice has been modified by the introduction of alkali metal ions (such as Rb^+, K^+, NH_4^+ and substituted ammonium ions, sulfonic and carbonium ions), and iodide has been replaced by a variety of anions. New crystalline salts are rapidly screened for ionic conductivity by examining their NMR spectra. The narrowing of magnetic resonance absorption lines, caused by the translational motion of mobile ions, indicates that a compound may be an ionic conductor. So far, only silver ion conductors offer those properties required for the manufacture of most electrochemical components.

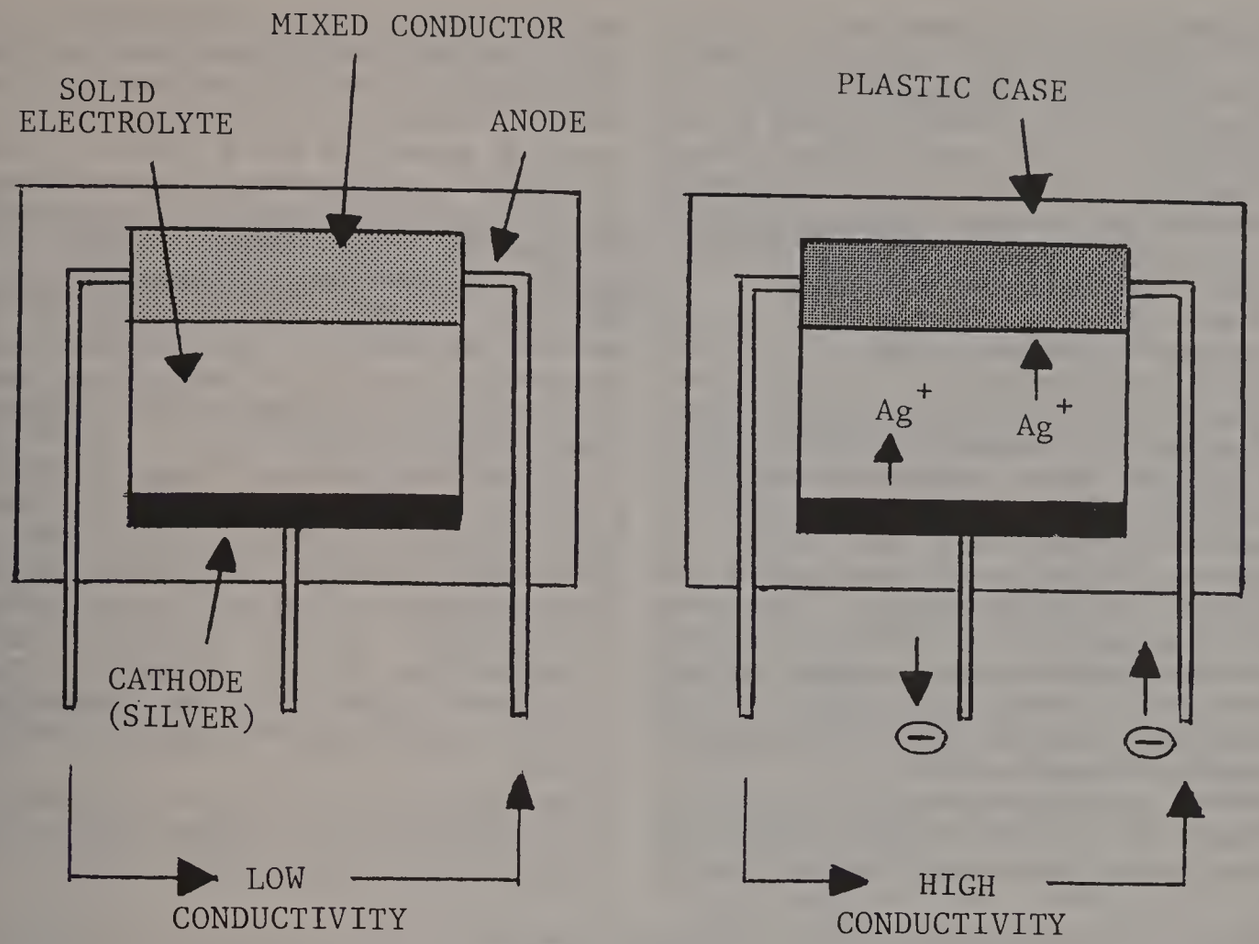
High conductivity of ionic silver conductors at room temperature can be attributed to two characteristics of the silver ion. Being monovalent, silver ions diffuse through a crystal lattice more readily than multiply-charged ions. Also, while silver ions generally form covalent bonds to four tetrahedrally-located ligands, they can bond to three ligands. That, in fact, is exactly what silver ions must do to escape from their "rest position" at the centre of tetrahedra formed by iodide or other negatively-charged ions. To hop into a void in the adjacent tetrahedron, a silver ion passes through an intermediate state in which it is bonded to three ions in the triangular face of a tetrahedron. This bonding configuration is compatible with the d shell orbital configuration of Ag^+. The only other monovalent ion with the same orbital configuration is Cu^+, which in the compound $Rb_4Cu_{16}I_7CI^{13}$, has the highest conductivity yet found in a super-ionic conductor at room temperature (0.34 ohm^{-1} cm^{-1}).

It should be noted that other ions, besides Ag^+ and Cu^+, have high ionic mobility at high temperature. One example is the ionic conductivity of sodium, lithium and hydrogen ions in ß-alumina, which is utilized in the design of high-temperature sodium/sulfur batteries. Fluoride ion conductors have appreciable conductivity even at room temperature and may be practical electrolytes for fluoride ion-selective electrodes and solid-state batteries. Doped zirconia, thoria and ceria conduct oxide ions at temperatures above 600^{0}C. These are used in oxygen sensors to monitor oxygen concentrations in boiler exhaust gases, or engine exhaust, and may be used to control combustion conditions in automobile engines.

The electrical conductivity of ionic semiconductors rises exponentially with temperature — as it does in electronic semiconductors. Ions with greater-than-average thermal energy can propel themselves through the passageways of the crystal lattice, crossing an energy barrier each time they hop from one tetrahedral site to the next. The energy barrier for ion hopping is about the same as the energy gap separating valence orbitals and the "conduction band" in silicon semiconductors. The conductivity of doped silicon arises from a small number of localized valence electrons which have enough thermal energy to push through this energy gap into the conduction band, in which electrons can migrate through the material. Conductivities of super-ionic conductors and silicon electronic conductors fall within the same range.



A sensor to monitor oxygen concentrations in hot exhaust gases of boilers or engines utilizes a salt which conducts oxide ions. On each side of the ion-conducting salt is an electrode permeable to oxygen gas. One electrode is exposed to oxygen-depleted exhaust gases; the other is exposed to air. The difference in oxygen concentration causes some atmospheric oxygen to be reduced to oxide ions, migrate through the conductive salt, and be oxidized back to oxygen gas. While no net reaction occurs in this electrochemical cell, except for the transfer of oxygen, the different oxygen concentrations in the exhaust gas and air generates a small voltage across the electrodes.



An electrochemical switch controls the flow of current by varying the chemical composition of silver - silver selenide mixed conductor. The mixed conductor has low electrical conductivity when little silver is present in the solid solution (depicted in diagram on left). Additional silver is electrodeposited when current flows from anode to cathode (depicted on right); silver is removed from the mixed conductor when current flows in the opposite direction.

Ionic semiconductors will not displace electronic semiconductors. For one thing, electrons move much faster than ions, so ionic devices are totally unsuitable for high-speed and high-frequency applications. In fact, electrochemical components perform best in precisely those low-speed applications for which electronic components are least efficient — for long-term storage of electrical signals (as in timers and integrators). Conventional circuitry uses capacitors to accumulate and store electrical signals, but these gradually lose their electrical charge through internal leakage. By contrast, a "Memoriode" electrochemical memory cell can store a small voltage for hours or days (without need for a power supply). After 48 hours, the stored voltage will have changed by less than 0.3% of its original value. The device, which is about the same size as other miniaturized solid-state components, can be charged or discharged to a new voltage level in a few seconds. Such low-speed electrochemical components might complement the function of high-speed silicon transistors and integrated circuits.

A preview of these applications was initially presented by Takehido Takahashi at a 1976 conference on super-ionic conductors*[1]. Some electrochemical components are now manufactured by Sanyo Electric Company's Component Division in Osaka (Japan), and are described in a recent publication, *Applications of Solid Electrolytes*[*2].

One of the newly-developed components is an electrochemical switching cell. The operation of this device is analogous to that of the widely-used electronic Silicon-Controlled Rectifier (SCR). The SCR does not conduct electricity between its two main power terminals until a small current is applied to a third "gate" electrode. This input signal triggers the SCR into conduction, and allows a massive current to flow through the device. When the current stops, or if the power supply is momentarily disconnected, the device will not "remember" if it had been triggered into conduction and will return to its non-conducting state. This is not so for the electrochemical switching cell, which "remembers" indefinitely the signal which has instructed it to be conducting, non-conducting or partially conducting.

Operation of the switching cell is based upon the conduction of silver ions by a thin slab of solid electrolyte. A silver metal cathode is deposited on one side of the electrolyte. On the other side is a layer of silver selenide, to which an electrical terminal is attached at each end (one terminal serves as an anode). The silver selenide will not, by itself, conduct an electron current between these two terminals. However, it forms a conductive solid solution when metallic silver is deposited by current flow from anode to cathode. The change in conductivity of the silver selenide layer is directly proportional to the total amount of elec-

trodeposited metal. Current flow in the opposite direction, from cathode to anode, removes silver from the mixed conductor. The conductivity of the mixed conductor is thus proportional to the total electrical charge (current x time) which has passed from anode to cathode, and provides a cummulative record of current flow. The cell can be used for memorizing or integrating electrical signals.

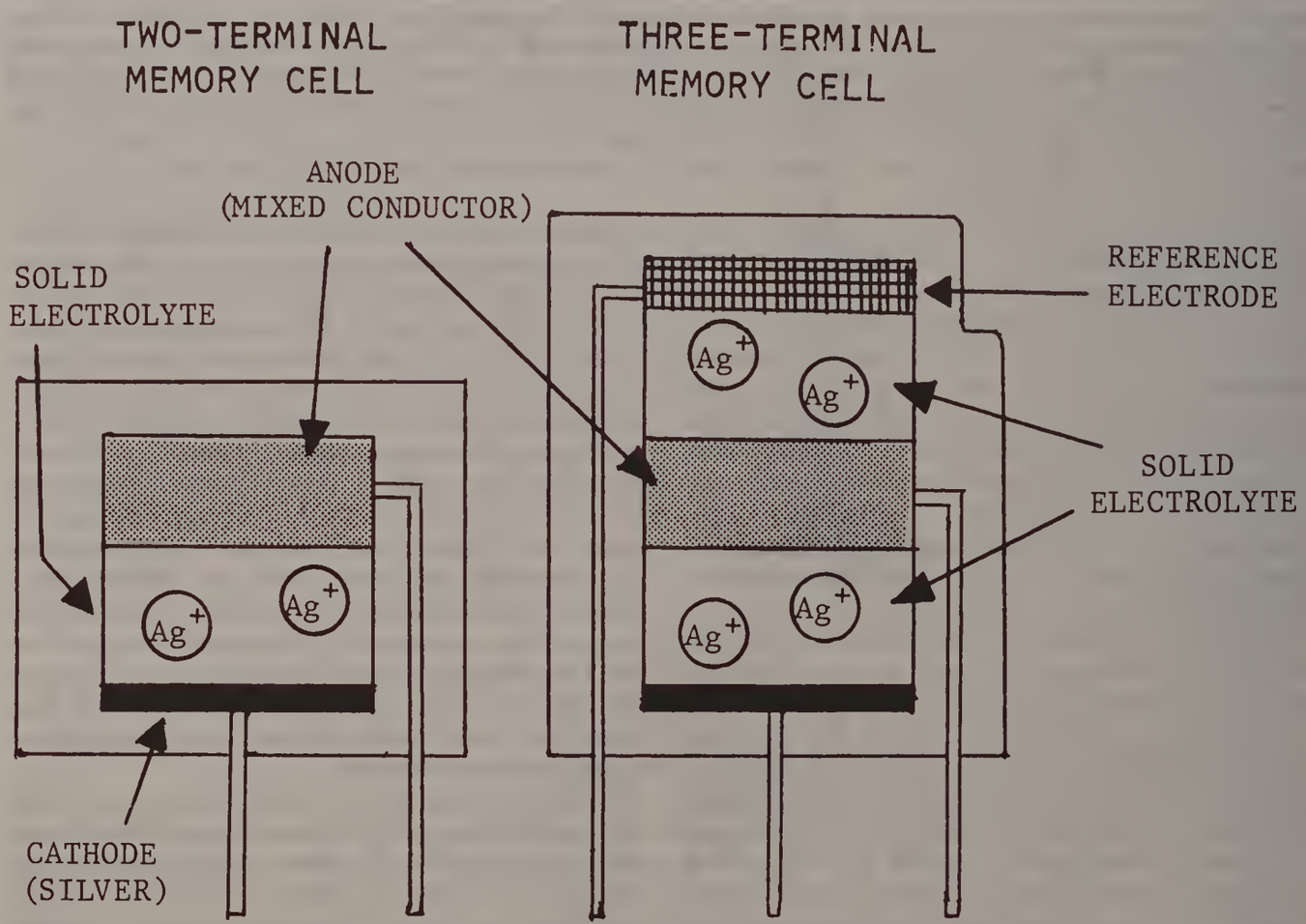
Another type of electrochemical component is the memory cell (memoriode). This cell also contains a solid electrolyte sandwiched between a silver electrode (cathode) and mixed conductor (anode). As in the switching cell, passage of an electrical current through this solid electrolyte deposits metallic silver in the mixed conductor. However, this cell does not "remember" this current by the change in conductivity of the mixed conductor — but rather by a potential difference. This small voltage (0 - 120 millivolts) arises from the increased concentration of silver in the mixed conductor, and appears between the cathode and anode of a two-terminal memory cell.

For the design of accomanying electronic circuitry, it is convenient to have this output voltage appear on a third electrode, which is isolated from the anode - cathode input current. A reference electrode and additional layer of solid electrolyte are thus employed in three-terminal memory cells. The output voltage increases in proportion to the cathode - anode current flow, and decreases to the same extent by anode - cathode current. The potential of the reference electrode provides a cummulative record of cathode - anode current. Changes in the output voltage (reflecting changes in the chemical composition of the mixed conductor) are reversible, and in fact, memory cells show little change in characteristics after a million charge - discharge cycles.

Yet another application of super-ionic conductors is in solid-state display systems. These could help meet the rapidly-expanding demand for solid-state displays, now provided almost entirely by electro-optical liquid crystal devices.

*1 *Proceedings of this conference were published as a book, "Superionic Conductors", edited by G. D. Mahan and W. L. Roth, Plenum Publishers, New York, 1976.*

*2 *Applications of Solid Electolytes, edited by T. Takahashi and A. Kozawa, Chapter 5, JEC Press (Cleveland, Ohio) 1980.*



An electrochemical memory cell serves exactly the same function as a capacitor, maintaining a small output voltage after charging with an input current. However, unlike a capacitor, a memory cell can maintain a constant output voltage for long periods. This stability is possible because the output voltage of the memory cell results from chemical changes induced by the input anode - cathode current. Silver is oxidized at the cathode, and Ag^+ ions migrate through the solid electrolyte. Silver ions are reduced to silver metal in the mixed conductor. The change in silver concentration in the mixed conductor causes the output voltage, which appears between the anode and cathode in a two-terminal memory cell (shown on left). In a three-terminal memory cell (on right), the output voltage appears between the anode and a reference electrode. This allows the output voltage to be electrically isolated from the input current.

Greater corrosion resistance imparted by electrodeposition of paint

One of the most effective and fastest-growing methods for coating metal is electropainting, or "electrodeposition" as it is often termed. Since its introduction by the Ford Motor Company in Europe in 1963, this revolutionary technique has been adopted by nearly all manufacturers to apply the prime coat (that is, the paint layer directly in contact with the metal surface) to automobile bodies, industrial components and appliances. More than 400 electrodeposition installations are operating in Europe and Japan alone. Nearly all car bodies manufactured in Europe and Japan, and half the car bodies made in the United States, are coated by electrodeposition. Of present electrodeposition installations, the great majority use *anodic* electrodeposition. However, recent development of a wide range of water-based *Cationic* resins and latexes will allow even better mechanical properties and corrosion protection to be achieved, as Dr. C. C. Ho pointed out to participants at the 1st Federation of Asian Chemical Society's seminar (held in conjunction with the 1981 congress of the Malaysian Institute of Chemistry). These advances, he indicated, could provide the impetus for this improved process to be universally adopted for coating metal parts.

The improvement and widespread application of cathodic electrodeposition will have enormous consequences for industry and the consumer. Corrosion often limits the useful lifetime of automobiles, structural members and vessels in chemical plants. In addition to the need for better corrosion protection, stringent requirements are being imposed for efficient and safe application of coatings, minimizing the escape of solvent vapours to the atmosphere, and improving the durability and appearance of coatings. Conventional paint formulations rely on the evaporation of organic solvents to deposit a polymer film on the coated article. These paints pose a safety (fire), toxicological and pollution hazard (from solvent fumes), and their use is becoming progressively more costly and legally unacceptable. As well as the loss of solvents, much of the paint solids are wasted with conventional application methods. With air spraying, as little as 50% of the paint actually ends up in the polymer coating. Paint may not reach inaccessible areas, or may have pinholes or cracks. This allows salts to reach the metal surface, initiating and accelerating corrosion.

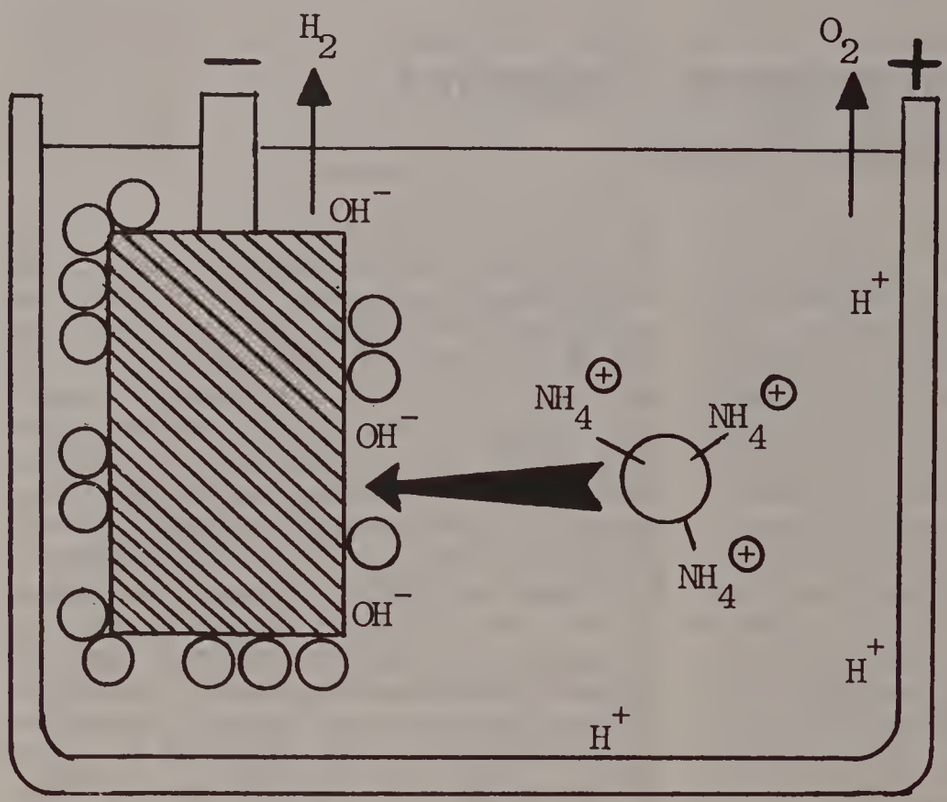
The inherent advantages of electrodeposition have long been apparent. Electrodeposition produces a uniform corrosion-resistant coating over the entire metal surface (covering welds and inaccessible recesses). Intricate parts, even entire automobile bodies, can be coated in one step. Electrodeposition employs a water-based paint medium, and thus does not release significant amounts of organic solvent to the environment. With the incorporation of recently-developed ultrafiltration recycling technology, virtually *all* paint material is actually applied to the metal surface. The process can utilize paint with essentially 100% efficiency, and can be virtually non-polluting. Improved corrosion and impact resistance are achieved, especially with cathodic electrodeposition. These potential advantages were apparent since electrodeposition was first conceived as a new coating method, but technological problems prevented their attainment for many years.

In the electropainting process, the metal piece to be coated is immersed in an aqueous paint solution containing electrically-charged polymer ions or latex particles. The electrical charge results from either carboxylic acid or amine groups on the polymer molecule, or adsorption of a charged surfactant onto the surface of polymer latex particles. An electrical potential (about 50 - 400 volts) is applied between the part to be coated and the metal bath holding the electrodeposition solution. This potential causes polymer ions to migrate through the solution and deposit on the piece to be coated. Pigments are encapsulated within the resin, and are carried along with the charged polymer molecule or particle. Since the deposited polymer is an electrical insulator, electrodeposition stops as soon as all surfaces are coated with a thin polymer coating of uniform thickness (20 microns).

The piece to be coated may serve as anode or cathode of the electrodeposition cell, depending upon whether the polymer resin carries a positive or negative charge. For the anodic process, polymer resins with carboxylic acid groups are generally used. A negative charge is imparted to the macro-ions by neutralization of the carboxylic acid groups with a base (alternately, the polymer resin can be formed into a latex by dispersal into fine droplets, which then absorb negatively-charged surfactant ions). Many different types of anodic resins have been developed, and for this reason, anodic electrodeposition has become far more common than the cathodic process—although it is inherently inferior.

During anodic electrodeposition, electrolysis of water generates oxygen gas and hydrogen

In cathodic electrodeposition, the object to be coated is immersed in a paint containing positively-charged particles of polymer resin dispersed in water. The positive charge arises from amine groups in the polymer macromolecule, which are protonated in the acid paint solution, or by adsorption of surfactant ions to resin particles in a latex.



When a negative potential is applied to the object to be coated (the cathode of the electrodeposition cell), resin particles migrate to its surface. There, hydrolysis of water generates hydroxide ions, which neutralize the positive charge and cause the resin to deposit on the metal surface. A uniform coating of polymer is applied to all metal surfaces in contact with the paint bath. Later, the coating is baked, causing the resin to polymerise into a pinhole-free film. Intricate parts or entire automobile bodies (such as the one shown here on a Malaysian production line) can be coated *(photograph courtesy of Dr. C. C. Ho, University of Malaya).*

ions at the metal piece to be coated. The hydrogen ions neutralize the negative charge on the polymer particles, causing uncharged resin to be deposited. However, the electrolysis reaction creates an oxidizing and acidic environment at the anode, and some dissolved metal ions may be incorporated into the coating. This may discolour the paint film and reduce its corrosion resistance. This limitation can be entirely avoided by cathodic electrodeposition, but until recently, only a limited number of cationic resins were available at relatively high cost.

Extensive research and development have now been devoted to the production of cationic resin systems with the required electrical characteristics, stability and film performance, and the range of usable polymers has been greatly extended. As a result, cathodic electro-

deposition is acquiring growing importance. Coatings produced with the new cathodic systems provide superior corrosion resistance, gloss retention and impact resistance.

In cathodic electrodeposition, a negative potential is applied to the piece to be coated. The paint solution generally contains a resin with amine groups on the polymer molecule. Protonation of the amine groups in the acid electropainting bath imparts a positive charge to the polymer molecules (or, once again, the electrical charge may be imparted by adsorption of surfactant ions onto dispersed latex particles).

When the electrical potential is applied, the positively-charged resin migrates towards the metal part to be coated. There, hydrolysis of water produces hydrogen gas and hydroxide ions. The alkaline environment at the surface of the metal piece neutralizes the charge on the polymer resin molecules, causing the polymer to deposit on the metal. After a few minutes, the coated part is removed from the bath, rinsed and baked. The small amount of residual water in the coating is driven off during baking, and the electrodeposited resin cures into a smooth, pin-hole-free film.

An important recent advance in electrodeposition technology is the introduction of ultrafiltration systems for paint recycling and pollution control. These systems allow paint particles to be recovered from "drag-out", paint solution that clings to the coated part when it is withdrawn from the electrodeposition bath. This paint is washed off with the rinse solution, which is pumped to the ultrafiltration unit. There, resin and pigment particles are unable to pass through the ultrafiltration membrane, and are concentrated and recycled to the electrodeposition bath. Water and solvents pass through the membrane, allowing the rinse solution to be recycled. Installation of an ultrafiltration recovery unit thus allows virtually 100% utilization of paint constituents, and obviates the need for waste treatment of plant effluents.

Installation of advanced electrodeposition technology will also affect our environment in a less subtle way. In addition to improved corrosion protection provided by cathodic electrodeposition, the coatings are expected to retain their original appearance throughout the operating lifetime of the part. In this way, electrodeposited coatings will literally colour our view of the world in the years to come.

RECENT REPORTS

Molecular luminescence spectroscopy

Part VI — Nomenclature, symbols, units and their usage in spectrochemical analysis *(Provisional)*

This paper introduces new symbols, units and nomenclature not previously published in the series of documents on spectrochemical methods of analysis prepared by Commission V.4. In producing this document, an attempt has been made to select a consistent set of symbols from those used at the present time and recommending new symbols where previously there was ambiguity. In addition, the definitions of several luminescence parameters, in particular quantum yields and quantum efficiencies, have been clarified and the importance of strictly defining the term "corrected" as applied to luminescent quantities has been emphasised. Despite the wide use of photon quantities in publications on luminescence spectroscopy and photochemistry, there is a lack of consensus on the symbols which should be used. This document recommends the use of subscript p on the energy unit to denote the corresponding photon quantity. The proper procedure for converting from energy units and photon quantities is also discussed.

This report was prepared by W. H. Melhuish for the Commission of Spectrochemical and other Optical Procedures for Analysis, and will be published in *Pure & Applied Chemistry*. Comments may be addressed to the Commission Secretary, Mr. R. Jenkins, Philips Electronic Instruments Inc, 85 McKee Drive, Mahwah, New Jersey 07430, USA.

Recommendations for publishing manuscripts on ion-selective electrodes *(Provisional)*

This report describes recommendations and suggestions to authors contemplating publishing papers in the field of ion-selective electrodes. These were developed by the Analytical Nomenclature Commission (V.3), in collaboration with other IUPAC commissions and recognized authorities in this area. This final draft incorporates all suggestions made by members of the Analytical Division Committee, as well as those made by other individuals on the Provisional Report.

The sections of the report include: definitions of most frequently used terms recommended for use by the author, information recommended when publishing papers on new or modified electrodes, applications for direct concentration measurements, titration applications, and on-line process applications and automated methods.

This report was prepared by Prof. G. G. Guilbault for the Commission on Analytical Nomenclature, and is to be published in *Pure & Applied Chemistry*. Commments may be addressed to the Commission's Secretary, Dr. G. Svehla, Department of Chemistry, David Keir Building, Queen's University of Belfast, Belfast BT 5AG, Northern Ireland.

Transport phenomena in electrolytic systems

The document is an Appendix to the Manual of Symbols and Terminology for Physicochemical Quantities and Units. It deals with the transport phenomena of importance to electrochemists and electrochemical engineers. In the absence of a report on mass transport at large, the first section presents general definitions of mass flux, flux density and of phenomenological coefficients, as appearing in the relationship of irreversible thermodynamics, which express the proportionality between the driving forces and the fluxes. The main part is concerned with electrolytic systems, in particular with ideal dilute solutions. Mass transport by diffusion, by convection and by migration of ions under the influence of an electric field is considered. The diffusion coefficient of a species is distinguished from that of an electrolyte. A section is devoted to the transport of charges, including transport numbers, the flow of current through the solution and through the electrode, current efficiency, and current distribution. The report also discusses the precise meaning of concepts related to mass transport, such as the Nernst diffusion layer, mass transport control, interfacial concentrations, concentration overpotential, mass transport coefficients and diffusion potentials. However, the diffusion in solid electrolytes and surface diffusion are not treated.

Recommendations for symbols and definitions are given. In many cases, it is endeavoured to clarify by a brief discussion the concept itself.

This report was prepared by Prof. N. Ibl for the Commission on Electrochemistry, and will soon be published in *Pure & Applied Chemistry.* Comments may be sent to the Commission Secretary, Dr. J. C. *Justice, Laboratoire d'Electrochemie, Universite* Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cedex 05, France.

Nomenclature for thermal analysis — Part IV *(Provisional)*

Developments in thermal analysis over the past decade or so have revealed some shortcomings in the recommendations made in the first report drawn up in 1968 (See *Pure Appl. Chem.* 1974, *37,* 439 - 444): moreover, some techniques then regarded as minor have come into prominence with time. In consequence, the definition of *thermal analysis* has been recast and rephrased in such a way that replacement of only a few words is necessary to define each of the principal techniques falling within its bounds. These techniques (some 17 in all) are classified on the basis of the physical property — e.g. mass, enthalpy, dimensions, etc. — whose change with temperature is measured and a limited number of approved abbreviations are listed: some subsidiary techniques are also referred to. This report, originally prepared by the Nomenclature Committee of the International Confederation for Thermal Analysis (ICTA), was approved by the Council of ICTA in 1977. It will be published by ICTA and the Commission on Analytical Nomenclature in *Pure & Applied Chemistry,* Volume 53, No.8 (August 1981).

Presentation of Raman Spectra in data collections

This report recommends parameters that should be specified when Raman spectral data are presented. Specifications are given in terms of three classes of data — critically defined physical data, research quality analytical spectra, and approved analytical spectra. (Spectra not falling into one of these classes are regarded as "unevaluated spectra.") Specifications cover all important aspects—the sample, the excitation source, the Raman spectrometer itself, and the overall experimental configuration, including measuring techniques for determination of depolarization ratios. This report is a very slightly modified version of Provisional Recommendations that were published by the *IUPAC Information Bulletin,* No. 2 (1978).

Prepared by Dr. E. D. Becher for the Commission on Molecular Structure and Spectroscopy, the report will shortly be published in *Pure & Applied Chemistry.* Comments may be addressed to the Commission Secretary, Prof. G. Zerbi, Instituto di Chimica Industriale del Politecnico, Piazza Leonardo da Vinci 32, I-20133 Milano, Italy.

Calorimetric measurements on cellular systems:
Recommendations for measurements & presentation of results *(Provisional)*

Calorimetric measurements are of basic importance in studies of the thermodynamic properties of living systems. However, currently most calorimetric investigations on cellular systems are undertaken as parts of diagnostic studies without the objective of acquiring thermodynamic information. The Commission offers in this report some recommendations with the aim to increase the usefulness of the thermodynamic quantities determined in such studies. It is believed that adherence to the recommendations will also be of value in purely "diagnostic" calorimetric work in this field.

The document contains a summary of relevant SI units and symbols for units, together with some comments on their use in connection with calorimetric studies on cellular systems. Some specific recommendations for this field are made concerning experimental details and on the procedures for reporting of results.

Brief comments are made on the interpretation of heat quantities associated with growth processes.

The report was prepared by E. F. Westrum Jr. for the Interunion Commission on Biothermodynamics (containing members from IUPAC and the International Unions dealing with Biochemistry and Applied Biophysics). It will be published in both *Pure & Applied Chemistry* and in the *CODATA Bulletin.* Comments may be sent to Prof. I. Wadso, Chemical Center, Thermochemistry, University of Lund, POB 740, S-220 07 Lund 7, Sweden.

Isotopically modified compounds (Part II.1, Nomenclature of Inorganic Chemistry)

A general system for describing isotopically modified inorganic compounds, in both names and formulae, has been published by the IUPAC Commission on the Nomenclature of Inorganic Chemistry. This treatment follows closely that developed for organic compounds (Pure and Applied Chemistry, 1979, *51*, 353 - 380). Various types of isotopically modified compounds are defined and rules are given for describing them. Isotopically enriched (labelled) compounds of various types are treated and also those in which isotopic replacement is complete.

This report was prepared by Dr. T. D. Coyle for the Commission on Nomenclature of Inorganic Chemistry, and will be published in *Pure & Applied Chemistry*. Comments may be sent to Dr. Coyle at the Chemical Stability and Corrosion Division, National Bureau of Standards, US Department of Commerce, Washington D.C. 20234, USA.

Assignment & presentation of uncertainties of the numerical results of thermodynamic measurements *(Provisional)*

A report of the IUPAC Commission I.2 on Thermodynamics prepared by the Subcommittee on the assignment and presentation of uncertainties of thermodynamic results. (To be published in Pure Appl. Chem. and J. Chem. Thermodynamics.)

In 1972 the IUPAC Commission I.2 on Thermodynamics and Thermochemistry published its "Guide to procedures for the publication of thermodynamic data" (Pure Appl. Chem. *1972*, 29, 397), which set detailed requirements to be met in the description of experiments. The purpose of the present report is to supplement the 1972 report as a suggested guide for the assignment and presentation of the uncertainty of the experimental results.

The report presents a small consistent set of symbols, which are recommended for use in the presentation of uncertainties. The discussions in the report are based on a classification of uncertainties associated with numerical results into three defined categories. Ways of combining various types of uncertainties by the use of "propagation of error" formulas are indicated. The evaluation of functional relations using least-squares techniques is discussed. Discussions are given on the presentation of uncertainties of thermochemical calorimetric measurements, of thermophysical calorimetric measurements, of non-calorimetric thermophysical measurements and of other equilibrium measurements. References are given to papers, which identify sources of uncertainties in various types of experiments and discuss procedures to estimate the influence of such uncertainties on the final results. It is recommended that authors should study relevant parts of the report before expressing the uncertainties associated with their results.

The report was prepared by Prof. M. L. McGlashan for the Commission on Thermodynamics. It will be published in *Pure & Applied Chemistry* and in the *Journal of Chemical Thermodynamics*. Comments may be sent to the Commission Secretary, Prof. G. M. Schneider, Institut fur Physikalische Chemie der Ruhr-Universitat Bochum, D-4630 Bochum-Querenburg, Federal Republic of Germany.

Nomenclature for regular single-strand & quasi single-strand inorganic and coordination polymers *(Provisional)*

The fundamental principles of polymer nomenclature, which were developed to provide a frame-work for the unambiguous systematic naming of single-strand organic polymers, are extended to embrace inorganic and coordination polymers. The structures treated are regular single-strand polymers, that is polymers comprising repeating units linked exclusively through single atoms, and regular quasi-single-strand polymers, in which each repeating unit terminates at a single atom on one side but at a plurality of atoms on the other.

The name of the polymer is the name of the constitutional repeating unit (CRU) prefixed by the terms "poly", "*catena*", or other appropriate structural indicator, the CRU in turn being named by citing, in order of appearance along the chain, of its constituent sub-units, which are the largest structural fragments of the CRU that can be named according to established principles of inorganic and/or coordination nomenclature.

The document contains rules for the identification and orientation of the CRU, and it contains many examples of inorganic/coordination polymer structures together with the recommended names.

This report was prepared by Dr. W. H. Powell for the Commission on Macromolecular Nomenclature and the Commission on Nomenclature of Inorganic Chemistry. It will soon be published in *Pure & Applied Chemistry*.

IUPAC welcomes comments on its nomenclature recommendations, especially those published as provisional reports. Especially desired are comments about the use of proposed nomenclature in languages other than English. Comments should be sent to the address indicated within eight months of publication of a nomenclature report.

Chemistry will be the driving force accelerating the development of Asia

The rate of economic growth has slowed in the industrialized countries of Western Europe and North America. For these countries to overcome their dependence on petroleum and other scarce raw materials, they must re-align their economic and social systems. They face the challenge of maintaining their standard of living in an era of little or no economic growth. A very different outlook, however is projected for the countries of Asia.

The Southeast Asian region has tremendous potential for economic growth. Its population of 240 million people is equal to the European Economic Community, or to the combined population of the United States and Canada. It produces 83% of the world's natural rubber, 80% of its palm oil, 70% of its tin, and a significant fraction of the global production of sugar, coffee, wood, petroleum and coal. Major deposits of petroleum have recently been discovered in Malaysia, and Singapore has begun construction of a massive petrochemical complex which will produce ethylene, propylene, acetylene and aromatics for local chemical industries. Australia has enormous coal reserves, oil shale deposits and large semi-desert areas ideally suited for solar energy production.

If Asia has been a sleeping industrial giant, it will awaken to a technological climate entirely different from that experienced by Western countries 60 years ago. Asian nations cannot simply follow the same course of industrial development as was pursued so successfully by others earlier in this century. The future industries of Asia, those to be built now, cannot be fed and powered by petrochemicals. Large deposits of petroleum have been discovered in Asia, but these will not provide a major source of chemical feedstocks for the 21st century. Rather, they could provide an economic catapult to develop the infrastructure for the future chemical industry. Once developed, the Asian chemical industry could be closely linked with agriculture — upgrading and utilizing the agricultural production of oils, cellulose and natural fibres; and providing fertilizer and other agricultural chemicals.

by Dr. Martin Gellender
Editor, Chemistry International

Utilization of alternative raw materials to replace petrochemicals will place great emphasis on the development of new chemical processes. There is little doubt that such chemical processes will form an integral part of the framework for development in Asia. What remains to be resolved is how natural resources and chemical know-how could best be utilized to meet the objectives of industrial development in Asia, and exactly what these objectives should be. To clarify these issues, the Federation of Asian Chemical Societies (FACS) convened a seminar on "The Priorities of Chemistry in the Development of Asia" which was held in Kuala Lumpur (Malaysia) in conjunction with the Annual Chemistry Congress of the Malaysian Institute of Chemistry. The same theme also emerged in the technical sessions of the First Asian & Pacific Chemistry Congress held in Singapore from 26 April to 1 May 1981, immediately following the Malaysian meeting.

One view voiced repeatedly by seminar and conference speakers is that Asian countries will need to exploit renewable sources of fuel and chemicals. Many of these substances had already been used before the advent of cheap petroleum-based chemicals. One example is abaca fibre, which was formerly grown in the Philippines. This fibre has properties similar to nylon. Abaca fibre was displaced by nylon — not because its properties are inferior (in fact, it offers superior resistance to sea water), but because it could not compete with syn-

thetic fibres made from cheap and presumably unlimited petrochemicals.

Another example is natural rubber, which has been replaced in many applications by synthetic polymers. This trend will very likely be reversed. By chemical modification of the natural rubber molecule, researchers have been able to produce natural polymers with properties that could formerly only be obtained with synthetic materials. Such processes as cyclization and epoxidation of the natural rubber molecule, points out Tan Sri Sekhar (Chairman of the International Rubber Research and Development Board, and new president of FACS), can impart oil resistance and gas impermeability to natural rubber products. However, Dr. Sekhar dismissed the possibility, suggested some years before, that natural rubber could be pyrolysed to produce liquid hydrocarbon fuels. Other conference speakers agreed that this is not a practical process. A more direct and efficient alternative, they argued, is simply to make greater use of natural rubber in tyres, seals and other elastomer products, and thereby use less petrochemicals to make synthetic rubber.

The large scale production of vegetable oils in some Asian countries could certainly be utilized as a source of chemicals and fuel. Malaysia is the world's largest producer of palm oil, and the prospect for development of oleo-chemical complexes is certainly attractive. Fatty acids, fatty alcohols and glycerine could serve as feedstocks for a range of secondary chemical industries. In the Philippines, a chemical complex using coconut oil to produce fatty acid has recently been built.

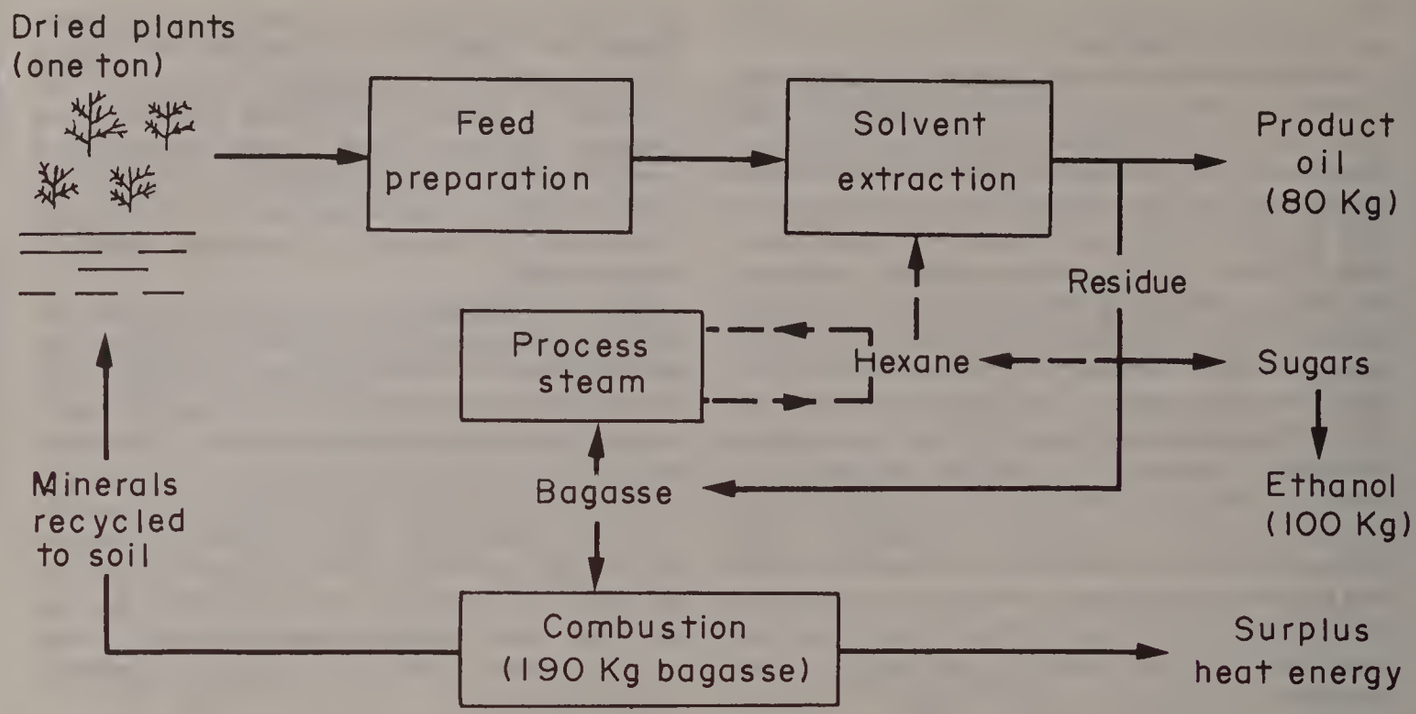
In order for Asian countries to successfully expand their production of chemicals from natural products, they must develop appropriate small-scale chemical processes. This was cited as a priority area for research & development by Hugh Grayson (President of the Royal Australian Chemical Institute). He described how Australian researchers developed new processes for use in mini-chemical industries supplying small local markets in Australia and Australasia. Already in operation is a process for making hydrogen peroxide (developed by Laporte of Australia), a process for making phthalocyanine pigments, and the "solid phase fermentation process" for small-scale production of ethanol from sugar processing waste (developed by CSIRO, the Commonwealth Scientific & Industrial Research Organization).

While the production of chemicals (which are high-value products) presents exciting challenges for the development of new processes, it is hoped that fuels can be produced with a minimum amount of chemical upgrading or refining. In fact, little or no upgrading is required for vegetable oils to be used as fuels in standard diesel engines. During the second world war, Malaysians ran their diesel engines on palm oil. The possibility of establishing vegetable oil plantations in Australia to provide diesel fuel was one of the options being investigated by CSIRO, and Dr. C. C. Curtain noted that rapeseed oil is presently being evaluated.

Chemically, vegetable oils are glycerol esters of long-chain fatty acids. They are formed when photosynthetic plants reduce atmospheric carbon dioxide. The reduction is nearly, but not quite complete, and it would be very convenient if green plants were able to reduce carbon dioxide all the way to hydrocarbons. Such plants do indeed exist. The best known is the rubber tree, *Hevea brasiliensis,* which produces large hydrocarbon polymer molecules (typically containing about 60 carbon atoms). Other plants have been investigated which produce hydrocarbons by essentially the same synthesis route, but terminate growth of the hydrocarbon product molecule when it is a light oil (containing about 15 or 30 carbon atoms).

A most remarkable plant which does this, as nobel laureate Prof. Melvin Calvin explained in his plenary lecture at the Asian and Pacific Chemistry Congress, is a tree which behaves as a renewable oil well. It pro-

The replacement of petrochemicals by plant-derived hydrocarbons is advocated by these two men, shown here discussing their views just before Prof. Melvin Calvin (right) presented his lecture at the 1st Asian & Pacific Chemistry Congress. Prof. Calvin argued that hydrocarbon oils extracted from plants could be substituted directly for petroleum as a source of fuel and chemicals. Dr. Sekhar (left) suggests that chemically-modified natural rubber could replace synthetic rubber in many applications, and thereby reduce consumption of butadiene, styrene and other chemicals used to make synthetic polymers.



Oil-producing Euphorbia plants will be processed in much the same way as vegetable oils are now extracted from oilseed plants. Once extracted, the hydrocarbon oil can be refined in conventional cracking units, yielding a mixture of liquid fuels and gaseous products. Euphorbia plants, unlike sugar cane and other energy-producing crops, can be cultivated in semi-desert areas with poor soil and low rainfall.

duces a hydrocarbon product, a clear liquid which looks like olive oil and literally pours out when a hole is drilled horizontally into the tree. About 25 litres of oil are collected from each tap hole, which is plugged for a six month period, while more oil is produced by the tree and collects in the canals running vertically through its trunk. A tree with one tap hole (and it is possible that several tap holes can be drilled) can thus produce 50 litres of hydrocarbon oil each year. The oil, containing only C_{15} sesquiterpenes, can be used directly as diesel fuel with no processing whatsoever.

This extraordinary tree grows only in the tropics. It reaches a height of about 15 metres and a diameter up to one metre. Originally identified in Brazil, the Brazilians are now attempting to grow the tree in plantations. The requirements for a tropical climate virtually eliminates the possibility that this hydrocarbon-producing plant could be grown in the United States or Western Europe, but many Asian countries are situated in the tropics and may be able to cultivate it.

Prof. Calvin has focussed his attention on hydrocarbon-producing *Euphorbia* plants, especially the species *Euphorbia lathyrus.* These plants are well-suited for cultivation in the semi-desert regions of the world, including the southwestern USA and nearly the entire Australian continent. They can tolerate high salinity (as is found in some coastal areas of Australia) and drought. At present, land in arid regions can only be utilized for grazing, and is not suited for the growth of food crops. For this reason, as Prof. Calvin emphasized, *Euphorbia lathyrus* should not be compared directly with other agricultural sources of biomass and liquid fuels (such as ethanol made from sugar cane). However, of all the plants now being considered as potential sources of liquid fuel, *Euphorbia lathyrus* has the highest yield of fuel energy (per acre-year) *per unit of rainfall.* The plant will grow in areas receiving only 10cm of annual rainfall, and will provide a marketable yield of hydrocarbon product with 25 - 30cm rainfall.

To recover the hydrocarbon latex from *Euphorbia lathyrus,* the plant is cut, dried, and the oil extracted with hexane (in the same way as vegetable oil is extracted from oilseed plants). Each metric ton of dried plant matter yields 80 kilograms of hydrocarbon oil. Also produced is 260 kg of sugar, which can be fermented to ethyl alcohol. Some of the dry plant residue, termed "bagasse", would be burned to provide steam for recovery of the hexane solvent. Remaining bagasse, about 190 kg, could be burned as fuel. Burning of the bagasse leaves an ash containing the phosphate and other minerals which had been assimilated by the plant. These minerals can be recycled to the soil. Only the original nitrogen content of the plant is lost when the bagasse is burned.

The hydrocarbon oil produced by *Euphorbia lathyrus* would be refined in a catalytic cracker, much as petroleum is now processed. Cracking yields a hydrocarbon mixture of liquid fuels and chemical feedstocks (containing about 55% liquid hydrocarbon with a high content of toluene and xylenes, 20% ethylene and propylene, 10% gaseous alkene and 10% fuel oil).

The first attempts to cultivate and process *Euphorbia lathyrus* on a significant scale are now beginning, although Prof. Calvin does not necessarily believe that this plant will prove best suited for oil production, or for cultivation in all countries. *Euphorbia lathyrus* is only one species among 2000 *Euphorbia* plants. These vary in size and shape, but all produce a hydrocarbon latex. Only about 15 or 20 plants have yet been examined, and among this initial group, *Euphorbia lathyrus* appears to have the greatest potential (curiously, this was the first plant tested by Prof. Calvin and his coworkers). Other *Euphorbia* species have been observed growing wild in Spain, Italy and in various countries of Africa, and these plants might be well suited for cultivation in these countries.

Such plants could certainly help free Asian countries from a dependence on petroleum-derived fuels and chemicals. The need to do so is crucial, Prof. Calvin emphasized, dismissing the long-term significance of possible future discoveries of petroleum in the Asian region. The prospect of finding or even developing new petroleum resources, he contends, will become progressively dimmer in the 1990's. While the present price of oil is determined largely by political actions of producer and consumer nations, the diminishing availability of fossil fuels will eventually preclude further exploration and exploitation — regardless of the price of oil. Prof. Calvin presented data which showed that the amount of oil produced *for each meter of well drilled* has declined steadily, and is now about half as much as in 1945. During the same period, as deeper and less accessible petroleum deposits have been tapped, the energy required to drill and extract petroleum has risen steadily. About the end of this century, according to Prof. Calvin's projections, the energy required to recover petroleum from newly-discovered deposits would be as much as the energy value of the petroleum. Then, the development of new petroleum resources would not only be uneconomic, but would be entirely pointless.

Priorities for development

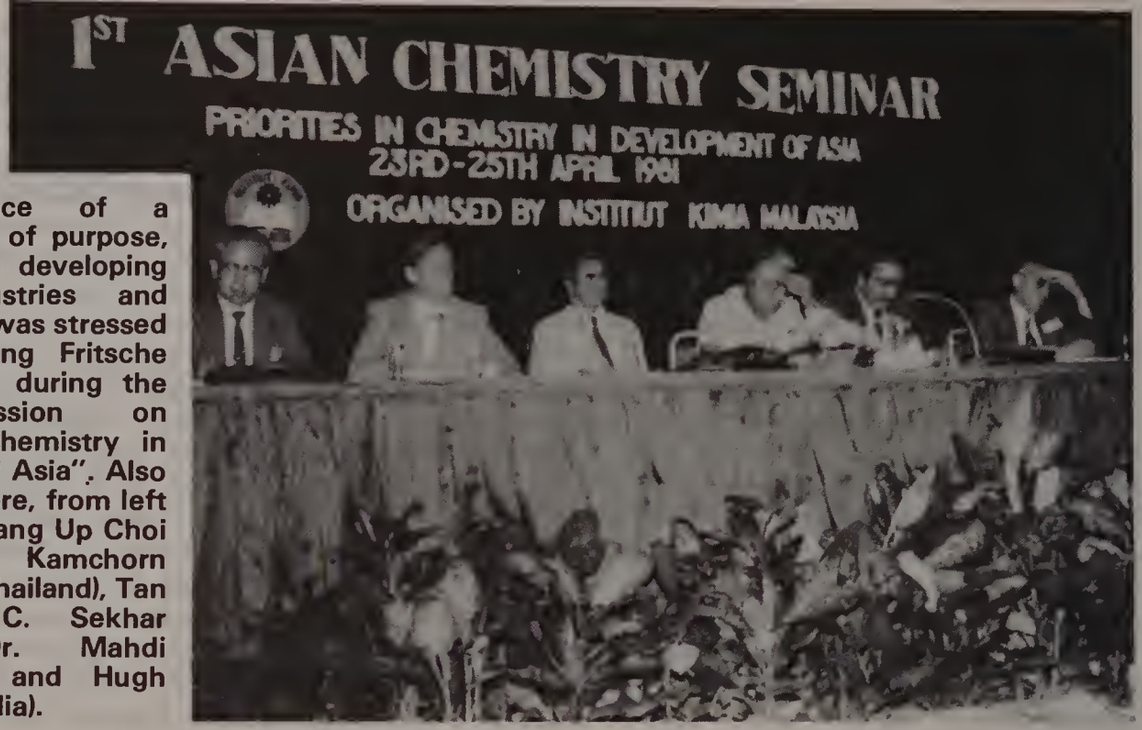
By developing their chemical industries in the post-petroleum era, Asian countries should be able to largely avoid the disruptive effect of raw material shortages in the 21st century. In other ways as well, industrial development in the 1980's offers other potential advantages. Asian countries can recognize — and avoid — mistakes made in other nations during the period of intensive industrialization earlier in this century. The consequences of these mistakes, asserted Dr. Wolfgang Fritsche (Secretary of the Federation of European Chemical Societies), are now being felt by European chemical industries. He explained these problems during the panel session concluding the FACS seminar on "Priorities for Chemistry in the Development of Asia". People in the developed countries, Dr. Fritsche noted, are no longer proud of their industry. He attributed the bad public image of chemistry and industry to the isolation of chemists from the public, and the association of the chemical industry with pollution. Before a new chemical plant can now be built in the Federal Republic of Germany, Dr. Fritsche's home country, it is first necessary to overcome opposition by citizens groups. Some of these groups are simply opposed to any new industrial undertaking. Chemists in the developing countries, he urged, should take a more active role in communicating to the lay person and establish a climate of public relations in which new chemical industries can germinate.

The poor image of chemistry was also cited by Hugh Grayson, President of the Royal Australian Chemical Institute. Although he feels that the lay-person's regard for chemistry is now improving, first-rate students are discouraged from studying chemistry. Mr. Grayson emphasized the importance of chemical education, since graduates of universities and technical colleges will shape the chemical industry of the future. The development of new chemical industries is not simply a matter of introducing new technology, he stated, but depends on people and personal interactions. Mr. Grayson acknowledged that sophisticated chemical instruments are extremely useful and necessary tools, but he argued, *people* bring about innovations and ingenious solutions necessary to solve chemical problems. As an example, he pointed to the recently-formed Southeast Asian Network for the Chemistry of Natural Products. That network grew from the personal contact of an Australian chemistry professor (Prof. Jack Cannon) with his former doctoral student (Phichai Tovivich). That relationship expanded to encompass chemists in ten Asian countries involved with research on natural products. The thrust of Mr. Grayson's argument paralleled the conclusion of Dr. Tovivich himself in his discussion of the Southeast Asian Regional Network. What makes the network effective, Dr. Tovivich had explained, is the friendly interaction among participating individuals. He stated that "everything depends ultimately on the personal enthusiasm of the people responsible for making it work."

The need for skilled manpower, and educational systems able to provide needed skills, are not being overlooked by those responsible for shaping national education policies. They are applying increasing pressure for chemical education to be directed towards national objectives for industrial development. More emphasis is being placed on applied chemistry and "mission-oriented research" to provide technology urgently needed for development. This policy, although understandable, might be short-sighted and counterproductive, warned Dr. Rayson Huang (vice-chancellor of Hong Kong University). He agreed that universities should respond to national needs, but argued that their primary function is to provide a broad education for their students. Specific skills rapidly become out-of-date with changes in technology. What is needed, he maintains, are graduates who can think, innovate and adapt. Students who are trained to perform a specific pre-conceived role may be immediately employable upon graduation, but might not have the skills needed a decade later. What those skills might be, Dr. Huang maintains, is virtually impossible to predict.

Support for this argument came from Malcolm Frazer (Professor of Chemical Education at the University of East Anglia in the UK). He noted that too much emphasis has been placed on *knowledge* (chemical facts and theories), and too little on *skills*. Learning chemistry should not be the only objective of university education, stated Prof. Frazer. He believes that a chemical education should be a medium for teaching basic scientific skills. The ability to solve problems, design experiments, make decisions, obtain information and communicate with others are skills that will serve the chemistry graduate throughout his career, even if he no longer practices chemistry.

Many will not. Prof. Alexandra Kornhauser (Head


1ST ASIAN CHEMISTRY SEMINAR
PRIORITIES IN CHEMISTRY IN DEVELOPMENT OF ASIA
23RD-25TH APRIL 1981
ORGANISED BY INSTITUT KIMIA MALAYSIA

The importance of a common sense of purpose, shared by the developing chemical industries and people of Asia, was stressed by Dr. Wolfgang Fritsche (2nd from left) during the panel discussion on "priorities in chemistry in Development of Asia". Also participating were, from left to right, Prof. Sang Up Choi (Korea), Prof. Kamchorn manunapichu (Thailand), Tan Sri Dr. B. C. Sekhar (Malaysia), Dr. Mahdi Hnoosh (Iraq) and Hugh Grayson (Australia).

of the UNESCO Centre for Chemical Education at the University of Ljubljana, Yugoslavia) relayed her surprise when she discovered that a minority of chemistry graduates in Yugoslavia were actually employed in the chemical industry, or industries usually associated with chemistry. When she investigated this further, she found that 60% of French chemistry graduates are working in non-chemical industries and professions. Thus, adaptability appears to be the most important asset of chemistry graduates. Very likely Asian chemists will perform an even wider range of jobs than their European counterparts.

Especially in Asia, Dr. Huang Stressed, it is important that university education be directed at the intellectual development of the student, and not simply train the student for a specific job. He noted that chemistry is particularly suitable for a broad intellectual education. It is a uniquely well-balanced mixture of experimental facts and theories (it is more oriented towards experimentation than physics, he noted, but has greater emphasis on theoretical concepts than biology). Chemical education teaches students to work with their hands, a talent which they would probably not otherwise acquire in Asian society, which confers little status to blue-collar workers. The conceptual component of chemistry helps counteract the age-old tradition of learning by memorization, which remains entrenched in Asian culture. A chemical education nurtures the ability to make experimental observations and stimulates enquiry. These talents will be of utmost importance to the future chemists of Asia.

Industrial growth vs population growth

No matter how much Asia expands its industrial base, the standard of living of Asian people will not improve unless population growth is brought under control. This point was driven home by Carl Djerassi (Professor of Chemistry at Stamford University, USA). He warned that the present alarming rate of population growth in the developing countries will offset the benefits of technological and industrial progress, and sweep these countries backwards into a state of poverty and starvation. Even a modest 1% net annual growth in population (which has now been achieved in the USA, USSR and Japan), he pointed out, would cause the population to double in 69 years. A 3% annual growth, as is typical of many developing countries, would cause the population to double by the turn of the century.

If this trend continues the results would be unimaginable. The population of Mexico, now 70 million, would reach 600 million by the middle of the 21st century. When the potential consequences of this explosive growth were recognized a few years ago, family planning programmes were begun in Mexico. Nonetheless, even the most optimistic projections place the population of Mexico at 200 - 300 million by the mid-21st century.

Of course, it will not take this long for the impact of the population explosion to be felt, as Pierre Crabbe (Prof. of Chemistry at Missouri-Columbia, USA) pointed out. Each year, the population of India increases by 14 million people. This is as much as the entire population of Australia.

Explosive population growth is a relatively new phenomenon, which has resulted largely from the introduction of new technology into old social systems. In many countries of the world, families rely on their children to contribute to the family income and later, to support the parents when they are too old to work. This social system worked reasonably well for millenia. Parents would have many children, with the hope that 2 or 3 would survive to reach adulthood. World population grew very slowly, about 0.4% per annum, until about 1600 A.D. At that time, the global population was 500 million people. Probably because of improved sanitation and nutrition, infant mortality declined and the population began to grow at an accelerating rate. The global population doubled in the following 250 years (reaching 1 billion by 1850), doubled again in the following 80 years (reaching 2 billion by 1930), and then doubled again in the 35 years leading up to the present period.

While Professors Djerassi and Crabbe agreed on the magnitude and impending impact of world population growth, their opinions differed on where corrective measures could be most effectively directed. Prof. Djerassi did not expect fundamental development of new birth control "hardware" by the end of the century, but felt that rapid improvements could be made in "software" — that is, the social system which encourages or discourages use of existing birth control methods. He believed that the birth rate in India could be halved by modifying the social system, in a similar way as the People's Republic of China has moderated their population growth. One measure, reducing infant mortality to low levels, would eliminate the need for parents to have many children in order that a few survive. Establishing a functioning system of social security to provide old-age pensions would also relieve social pressures for parents to produce offspring. Raising educational levels — epecially for girls, and encouraging women of reproductive age to enter the labour force would exert a marked effect on reducing birth rates.

The crucial factor, Prof. Djerassi believes, is to establish the motivation for people to have fewer children. Only when they feel that it is in their interest to use the available birth control measures, then they will do so — even if this is contrary to the dictates of their religion.

Although Prof. Djerassi is optimistic about the impact that could be brought about by social changes, he is a self-confessed pessimist about the development of fundamentally new birth control devices. He points to total worldwide expenditure on birth control research of only 150 million dollars (about the cost of one sophisticated bomber plane). He is exasperated that birth control research, which has more bearing on the future survival and well-being of mankind than any other scientific endeavour, is given such low priority. Spending on birth control research (in real terms) has actually declined since 1973. Of the research that is carried out, about 90% is done in developed countries. There, the needs for new contraceptive devices are far less acute and are qualitatively different than the needs of developing countries, where the population explosion is actually taking place.

Prof. Djerassi believes that birth control methods will gain acceptance in developing countries in much the same way as modern medicine has — initially to provide a cure, and later for prevention. He predicts that abortion will initially become the major birth control method, and points to the need for further research in this area. To support his argument, he points to the contrasting roles of abortion as a birth control method in North America and India. Most abortions in the United States and Canada are performed on single teenagers, while in India, more than 90% of abortions are performed on older married women.

Prof. Djerassi takes aim at the concept of an "ideal contraceptive". The characteristics desired in a contraceptive device will vary, not only from country to country, but even within the lifetime of one individual. Different qualitities are sought in a birth control agent by a teenager, a working woman and a mother who wishes to space the birth of her children. The acceptability of a birth control method may be influenced by culture, socio-economic conditions, or religion. Finally, like all drugs, birth control agents have associated side-effects in at least some members of the population.

The scientific endeavor which has most bearing on the survival of mankind is the development of new birth control methods, points out Prof. Carl Djerassi, yet it is given pathetically little priority. He projects a bleak outlook for development of fundamentally new contraceptive methods, but does believe that population growth might be contained by wider use of existing contraceptive agents.

Within the bleak outlook projected by Prof. Djerassi, there are a few glimmers of optimism. In the long-term, he felt that a major advance could be achieved in the development of luteolytic agents, compounds that prevent secretion of progesterone (a hormone which prepares the body for pregnancy and inhibits ovulation). He projected that a once-a-month birth control pill could be developed which would only need to be taken following periods of intercourse. The barriers that impede the development of luteolytic agents are money, effort and — mostly — time. The development and extensive toxicological testing required for new contraceptive drugs would require 12 - 15 years, and even this could only be achieved with greater effort than is presently expended. In the short term, Prof. Djerassi believes that it

will be possible to develop a simple chemical analysis of urine hormone levels (using a simple dipstick colour test) so that women can detect the onset of ovulation (and thus avoid intercourse during the few days of peak fertility). Such a method would not involve ingestion of a drug, and would thus circumvent the need for extensive toxicological testing.

A more optimistic view on the prospects of developing new contraceptives agents was presented by Prof. Pierre Crabbe, who described the World Health Organizations programme on research & development of new contraceptive agents. In contrast with Prof. Djerassi's view, he predicted that anti-implantation agents might soon be widely available. Such contraceptive compounds would be taken after intercourse, and cause the fertilized egg to be ejected from the womb. Prof. Crabbe described the discovery of the first effective anti-implantation agent, anordrin, in the mid-1960's. Upon hearing of its use in China, reported in 1975, the World Health Organization decided to verify anordrin's effectiveness. WHO also established a programme to prepare structural analogues, hoping to identify other compounds with equal or greater implantation potency. One of the analogue compounds that was synthesized, dinordrin, was found to prevent implantation of the fertilized egg at one-twentieth the dose needed with anordrin. The World Health Organization has recently developed a method to synthesize this new contraceptive agent from readily-available compounds.

Prof. Crabbe also reported success in the development of long-acting (3 - 6 months) contraceptive injections. These compounds are esters, made by reacting steroidal hormones with various carboxylic acids. The esters are gradually hydrolyzed in the body, releasing the hormone at a continuous rate. In this WHO programme, centres at 14 countries have carried out the synthesis, analysis, quality control, purification and formulation of 380 new steroid esters. Four compounds were found to have greater activity than any pre-existing, long-acting contraceptives. These compounds will undergo further animal testing and pre-clinical trials.

Although Prof. Crabbes outlook was quite different to Prof. Djerassi's, both men were in complete agreement that decisive steps were needed to control population growth. One man emphasized the development of new contraceptive agents, while the other stressed the restructuring of social systems so that people were motivated to have fewer children. Clearly, the two are closely related, and it is essential that these two routes converge if the development of Asia is to improve the living standards of its people.

How far Asia will advance technologically will likely be apparent when the next Asian Chemistry Congress in convened, probably in India in January 1984. The Federation of Asian Chemical Societies plans to sponsor such conferences at three year intervals. Other activities of the FACS were also discussed by representatives of the eleven member chemical societies (located in Australia, Hong Kong, India, Indonesia, Iraq, Korea, Malaysia, the Philippines, Singapore, Sri Lanka and Thailand) who met during the FACS Regional Seminar on Priorities in Chemistry for the Development of Asia. They decided to establish an Annual Award for a research project noteworthy for its possible impact on the development of the Asian region. The Federation also decided to organize specialised courses, seminars or workshops to be held in different Asian countries, drawing upon the expertise available in member chemical societies. The first seminar is expected to deal with "Instrument Servicing and Problems". Applications for FACS membership were considered and approved for chemical societies in Bangladesh, New Zealand and Japan. At the conclusion of the FACS Executive Committee meeting, Prof. Kamchorn Manuapichu stepped down as FACS President, to be succeeded by Tan Sri Dr. B. C. Sekhar (President of the Institut Kimia Malaysia). The post of Secretary - General will be undertaken by Dr. M. Mohinder Singh. Dr. Mahdi Hnoosh (President of the Iraqi Chemist's Union and Secretary - General of the Union of Arab Chemists) was chosen as President - Elect.

For further information:
Conference proceedings of the 1st Asian & Pacific Chemistry Congress are available from the Honorable Secretary, Singapore National Institute of Chemisty, c/o Singapore Professional Centre, 129B, Block 23, Outram Park, Singapore 0316. The price is S$20, including postage.

Agriculture could provide chemicals to nurture Third World industries

Photosynthesis and microbial action can, together, produce all the basic chemicals and energy that man needs. These two processes synthesize virtually all the cellulose, starch, carbohydrates, proteins, fats and vitamins that exist. A part of world biomass production is consumed by people and livestock, but only 15% of the world land surface is presently used to grow food crops. The major part of the crop production (60%) is discarded as unused residue. The problem is to make better use of solar energy and microbial action in order to produce more food, fuel and chemicals from biomass and its residues.

Crops grown in the Third World have traditionally been utilized either to provide local food needs, or are exported as raw agricultural products. Cash earned from export sales is spent on imported manufactured goods, fuel and chemicals.

For most African countries, the cost of imported fuel and chemicals is increasing rapidly in relation to the revenue earned by exported products. Already in some parts of Africa, up to 40% of export earnings are spent on petroleum and petroleum products alone. This problem can only be overcome if African countries utilise their own renewable plant resources and agricultural wastes as sources of fuel and chemicals.

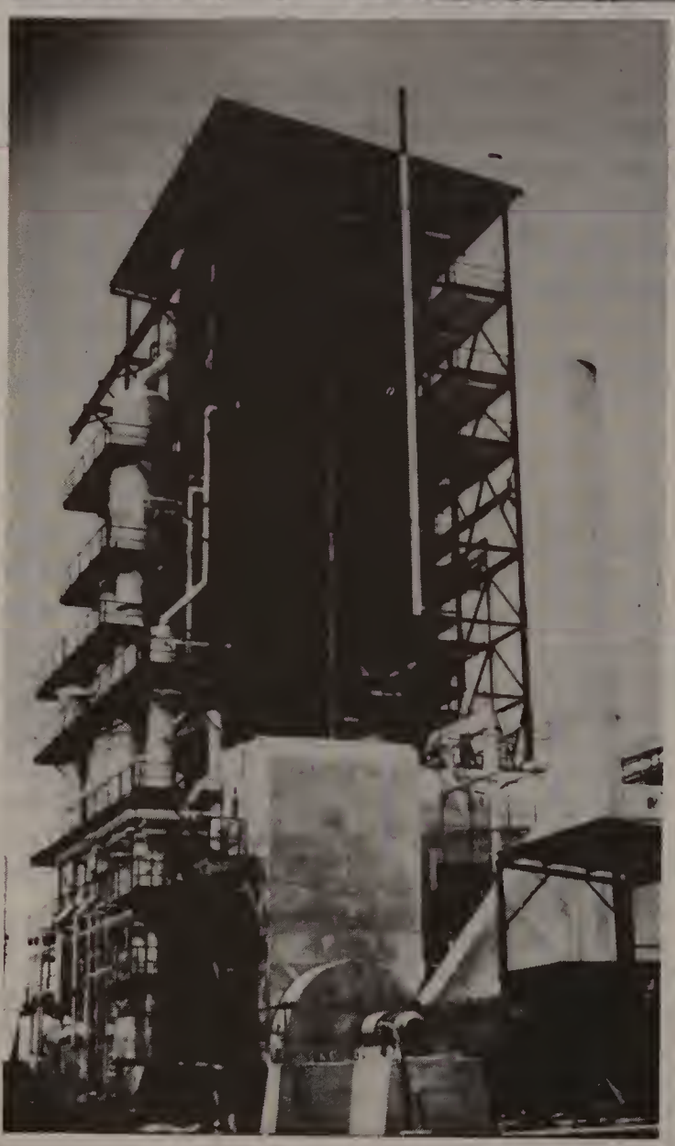
We are now much more aware of how synthetic fuels and industrially-imported chemicals can be produced from plants and waste biomass which abound in the Third World. Chemistry can play a major role in shaping the future of developing countries if agricultural policies are developed that encourage the exploitation of renewable sources of fuel and chemicals. It could provide the basis for new cash crops and new industries for rural populations.

by Prof. T. G. Bonner
University of London (UK)

All countries of the world face the problem of diminishing supply and increasing cost of petroleum. Each must seek new sources of fuel and chemicals that is appropriate for their future needs. Since plants grow more abundantly in tropical climates, agriculture could become a very important source of fuel and chemicals for the African continent.

The particular importance of chemistry in development has been recognised by UNESCO through the setting up of a new International Organization of Chemical Sciences for Development. This organization aims to bring together university and industrial chemists from the highly industrialised countries and Third World countries in a major cooperative effort to develop chemical resources of the Third World. If new labour-intensive rural chemical industries can be created, they will expand the purchasing power of rural villages, increase the demand for commodities, and encourage further development of manufacturing and agricultural industry. Such chemical industries, backed by an assured supply of renewable plant raw materials, will carry the brunt of rural and urban development. At the same time, they will diversify the range of commodities exported by Third World countries.

A wide range of possibilities exist to exploit biomass (plant matter) as a source of fuel and chemicals. To develop necessary technology will require a major reorientation towards applied chemistry, with the aim of establishing new labour-intensive rural industries.



A new chemical plant in Eldoret, Kenya utilizes maize cobs as the raw material, and produces furfural, acetic acid and formic acid. About 70 000 tons/year of maize cobs (which were formerly discarded as an agricultural waste product) are collected from nearby farms, stored at the plant (stockpiles are visible at lower left in the above photograph), and crushed. The ground cobs are then hydrolyzed in the central processing plant (shown close-up at left), using high-pressure steam in the presence of a catalyst. Volatile liquid products are recovered by distillation. The process also produces a solid residue which is used mostly as fuel for the plant boiler, but some will be carbonized into solid-fuel briquettes and sold as domestic fuel.

The plant will be in full production by the end of 1981. Annual production of the plant — 5300 tons of furfural, 3000 tons of acetic acid, and 300 tons of formic acid — will initially be exported to Europe and the Middle East, but eventually, the entire output of the plant should be used by secondary chemical industries to be established in East Africa. The same process could be adapted in other countries to utilize other natural fibrous waste materials, such as wood chips or oat husks *(Photographs courtesy of Guiness Peat Group Limited, UK).*

The first step in establishing a programme for the practical utilization of biomass is to carry out a survey of existing biomass resources in the particular country. The survey should assess which chemical processes might be developed. Interdisciplinary studies are necessary to identify those plants, microorganisms and environments which could be exploited to achieve the most rapid and secure economic progress. Close cooperation with chemical engineers, botanists, micobiologists, biochemists, agronomists and economists is essential. Simultaneously, another survey should consider the chemicals and fuels imported into the country, and raw materials which leave the country as exports.

To develop fermentation processes for the production of chemicals from biomass, an Applied Research & Development Unit should be created. A university chemistry department or similar institution is an appropriate setting, providing a pool of expertise, equipment and facilities. Post-doctoral research fellows can undertake specific studies planned by the Research & Development Unit.

Once necessary chemical technology has been developed, a government support should be sought to establish new chemical industries. Government bodies could provide part of the initial funding needed for new industrial facilities, with remaining capital provided by local entrepreneurs, cooperatives or foreign investment. Small-scale labour-intensive chemical industries have already been established in India, and any group undertaking biomass development should draw on the successful experience of the Institutes of Applied Science in India. Also of value are the large number of thorough studies prepared by the US National Academy of sciences Bureau of Science and Technology in Development (under the Chairmanship of Prof. Carl Djerassi). These studies deal with an extensive variety of tropical plants which have potential for economic development.

The chemistry department at the University of Nairobi has recently surveyed a number of chemical processes which could be utilised for industrial development in Kenya and other African countries.

These include:
(a) the production of alcohol from cassava, grown in arid and semi-arid regions.
(b) synthetic fibre and plastics industries based on furfural.
(c) a small-scale industry to extract castor oil from castor seeds.
(d) extraction of essential oils and medicinal compounds from indigenous plants.
(e) utilisation of wood as a source of chemicals.
(f) utilisation of the minerals trona and fluorospar.

To develop these possibilities into real chemical industries will require further laboratory studies and construction of operating pilot plants. Last year I had the very interesting assignment of preparing a plan, in cooperation with Professor Wandiga to set up an Applied Research & Development Unit in Chemistry, at the University of Nairobi. This undertaking will cost about US$4 million, and has been submitted for funding to UNDP (United Nations Development Programme).

One phase of the programme will be the undertaking of applied chemistry studies, carried out by an expert industrial chemist and a chemical engineer, four additional visiting research staff, and supporting research technicians. This team is to be appointed for a five year period, beginning in 1981, and would be integrated into the present teaching and research programme at the University of Nairobi.

A second aspect of the programme is the creation of a Masters-level course in Applied Chemistry and Chemical Engineering, to be planned in cooperation with the two research group leaders. Students taking this course would gain experience in pilot plant operation and in scaling up chemical processes for industrial applications. The extension of the chemistry department, building of pilot plant facilities and installation of new instruments is expected to lead eventually to the creation of a Department of Chemical Engineering and Technology at the University of Nairobi.

One promising technology which could form the basis of a major Third World industry is the processing of cassava, a tuberous plant (manioc esculente Krantz) which grows readily in Africa, Asia and South America. The whole plant could be utilized to produce a range of products: starch, glucose, alcohol, acetone and butanol could be produced from the tuber; and protein, methane, fibreboard and fertiliser made from the leaves and stalk.

The cassava tuber provides one of the highest yields of starch. It contains 30% starch, the remainder consisting predominantly of water. Starch is a valuable food product in itself, and can serve as a source of glucose and high-fructose syrups for the food industry. Village-scale industries can extract the starch, and process it into other chemical products.

The technology bearing most directly on the future use of cassava starch will likely be its conversion to glucose (by hydrolysis with enzymes), followed by alcohol production by yeast fermentation. The alcohol can be concentrated by distillation, and then blended with petroleum-derived hydrocarbons to make motor fuel. Alcohol has been used as an extender for gasoline for many years in Brazil. Brazilian production of alcohol is increasing every year and is expected to reach 10 000 million litres by 1985. Presently, sugar cane is used as the main source of glucose for fermentation, but no doubt, increasing use will be made of the expanding production of cassava in Brazil.

Prior to 1950, microbial fermentation processes were the main source of acetone and butanol, as well as alcohol. These compounds have since been synthesised from petroleum, but with the increasing price of petroleum, the fermentation process could again become economically viable. Fermentation of cassava with *Clostridium acetobutylium* (originally isolated from rice field soil) produces acetone and butanol, and also large quantities of the industrially-important gases carbon dioxide and hydrogen.

The leaves and stalks of the cassava plant contain appreciable amounts of protein (up to 30% protein on a dry weight basis). Its composition of amino acids is well-suited to meet human nutritional needs. The content of methionine, which is deficient, can be augmented from other inexpensive sources. Protein is readily extracted from cassava leaves by a screw

press or belt press. Fibrous residues can be compacted into fibreboard, or fermented anaerobically to produce methane-rich biogas fuel. Each of these operations could readily be carried out at the village level, and the products used locally.

Many other chemical products could be produced from plants and agricultural waste. Furfural, for example, is an important industrial solvent which has potential for utilisation in the plastics and synthetic fibre industry. It is obtained by acid or steam treatment of certain plants containing pentosans. Furfural can also be produced from wood. Recently, a simple process of obtaining furfural from waste maize cobs has been developed and a new plant has just been completed in Kenya for producing 5000 tons of furfural by this process. The entire furfural output was originally intended for export to meet the present high demand on world markets, but consideration is now being given to the possible use of furfural as a feedstock for new chemical industries to be developed in Africa.

The castor oil plant grows wild in East Africa. The seeds contain 40 - 50% oil, which is used in the manufacture of soap, paints, varnishes, and as a component of high-grade lubricants. In Kenya, it has been the practice to export castor seeds, and import extracted and purified castor oil back into the country at much higher cost. It is hoped that indigenous village-scale industries could be developed to extract and purify castor oil from the seeds. As well as being a potentially valuable export product, castor oil could be used by other village industries for the manufacture of soap, waxes, lubricants and other products. Besides castor oil, many similar vegetable oils could be produced from plants and seeds grown in Africa.

Molasses, or other glucose sources (such as cassava), can be fermented with *Aspergillus niger* to produce citric acid. This compound is used in enormous quantities (hundreds of thousands of tons annually) in the food and drink industries, and in the chemical, pharmaceutical, leather and textiles industries.

The same sources of glucose produce high yields of lactic acid when innoculated with *lactobacillus.* Lactic acid is usually esterified, and lactate esters are used as industrial solvents and plasticizers. A very important product made from lactic acid is methyl methacrylate, which is polymerized to form the plastic polymethylmethacrylate.

Euphorbia trees produce a latex whose composition of C_{20} - C_{30} hydrocarbons is essentially the same as petroleum-derived oil. These plants have been studied by Professor Calvin of the University of California, who reports that some species grow very rapidly in the soil and climate of Southern California. The plants also grow readily in semi-arid lands. One species *(Euphorbia lathyrus)* provides a latex yield equivalent to 25 barrels of oil per hectare of cropland. The cost of oil made by Euphorbia trees is projected to compare favourably with liquid petroleum fuels. It is believed that "hydrocarbon plantations" of Euphorbia plants will become an important future source of liquid fuels, especially as new species with higher oil yields are cultivated.

Wood is a rich potential source of chemicals. In addition to furfural, products such as methanol, acetone and acetic acid can be obtained by destructive distillation of wood. Liquid hydrocarbons are produced when wood is heated at 350^0C under pressure with hydrogen or carbon monoxide (see feature article about liquefaction of cellulose in *Chemistry International,* No. 4, 1980). Wood may also be gasified to hydrogen and carbon monoxide (synthesis gas). The gaseous product can be reacted to synthesize methanol, or the hydrogen reacted with nitrogen to produce ammonia (the basic feedstock of a nitrogen fertilizer industry). Finally, the high cellulose content of wood could eventually be utilised to produce glucose, from which alcohol or Single Cell Protein (SCP) could be made.

Over 60% of some agricultural food products are discarded as waste. This unutilised material, such as maize cobs, groundnut shells, coffee husks, straw and stalks of cereal crops, could be used as chemical sources. Many other waste products, such as juices in coffee kernels and cocoa beans, contain sugar. Their content of sugar could be recovered, and fermented to alcohol or used as a nutrient for growing SCP.

Single Cell Protein is produced by growing yeast or bacteria on a broth of starch or glucose. Any biomass which contains either of these nutrients could conceivably be used to produce protein for animal or human consumption (development of the first SCP product for human consumption is described in *Chemistry International,* February 1980). Several microorganisms can be used, including *Saccharomyces cerevisiae, Torula utilis* and *Candida tropicalis.* All convert glucose to protein with a yield of about 50%.

In this way, local chemical industries could convert unusable agricultural products to food. The use of biomass as a chemical feedstock might thus help meet the nutritional needs of the population, and not reduce food supplies by competing for available crop production capacity.

The two facets of phosphate

phosphate: essential for food production
phosphate: a threat to the environment

Phosphorus is essential to life and there is absolutely no substitute for this element as a plant nutrient and component of the human diet. Phosphorus is a constituent of DNA, RNA, ATP and other molecules essential for the functioning, growth and survival of all plant and animal organisms. The availability of phosphorus is often the factor that limits and regulates the growth of crop plants. Additional phosphorus fertilizer will be needed to expand agricultural production to meet the rapidly-growing demand for food. Yet ironically, this element has received wide publicity in recent years — not for its impending shortage, like that of fossil fuels — but for the excessive growth of algae and other aquatic plants caused by phosphorus-containing discharges.

Dr. M. A. Quddus
University of Malaya (Malaysia)

Phosphorus and nitrogen are essential for plant growth. Both elements are generally present in an inert form that plants cannot utilize directly: nitrogen is the main constituent of air, and phosphorus is contained in insoluble minerals or is complexed to metal ions. Weathering of apatite and other phosphate-containing minerals gradually releases orthophosphate ions (PO_4^{-3}), but the soluble phosphorus is quickly immobilized by iron, aluminium or calcium ions in the soil. Free orthophosphate is assimilated by plants, or is leached from the soil by rainwater.

In most natural environments, the limited supply of phosphorus controls the growth of vegetation. Discharge of phosphorus-containing waste can cause a lake or stream to become choked by uncontrolled growth of aquatic plants. For a short time after the phosphorus level becomes very high, the growth of plants might be limited by the supply of nitrogen, but only until blue-green algae begin to "fix" nitrogen from the air and produce nitrate. In fact, among all elements that are essential plant nutrients, phosphorus has been shown to be the primary cause of "eutrophication" of natural waterways.

The large-scale application of phosphorus in agriculture, industry and household products has led to increasing emissions of phosphorus into fresh and coastal waterways of Europe, North America and Japan. The use of polyphosphates in synthetic detergents (containing 10 - 30% phosphorus) is particularly significant and controversial, but no satisfactory substitute has yet been found. Various measures have been introduced to control phosphorus discharges to the environment. In some countries, like Sweden and Switzerland, advanced treatment methods have been installed to remove phosphorus from sewage. Governments in other countries, as Canada and some US states, have responded by imposing limits on the phosphorus content of washing powder.

However, the major share of all phosphates mined in the world today — 80% — is used in agriculture. It is generally thought that fertilizer phosphate that is not assimilated by crops is bound to soil constituents, but erosion releases much of the applied phosphate into lakes, streams and rivers. This diffuse source of phosphorus emissions is very difficult to control.

The extent of phosphate pollution in developing countries is unknown, as no systematic study has yet been undertaken in tropical conditions. It is generally thought that environmental phosphorus levels which permit uncontrolled algal growth are much less in the Tropics, where there is abundant sunlight throughout the year. The causes responsible for disruption of the natural phosphorus cycle — intensive agriculture, urbanization, deforestation, soil erosion, and increased consumption of detergents and other products — are very much apparent all over the developing world. Although developing countries are concerned with protection of their air and water environment, the possible consequences of uncontrolled phosphorus discharges are not yet generally recognised.

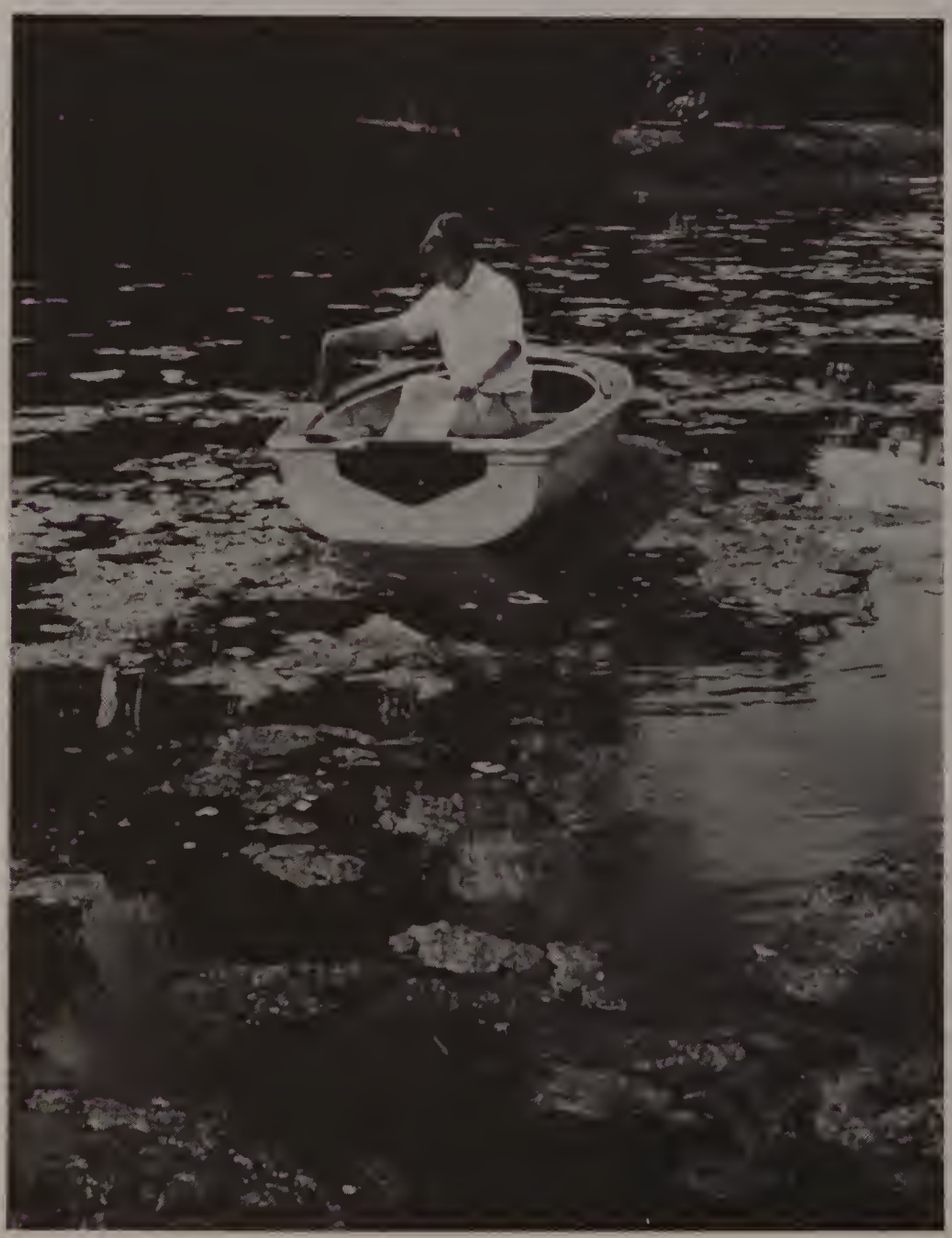
The immediate priority for these countries is to increase food production. This, no doubt, will require more intensive use of phosphorus, nitrogen and potassium fertilizer. According to one estimate, developing countries will need to increase their fertilizer consumption by more than 3 times during the next 20 years for food yields to simply keep pace with population growth. Because of recent sharp increases in the price of fuel and rock phosphate, however, it looks very doubtful whether these countries could meet such demands.

Another disturbing trend is the rate of urbanization all over Asia, Africa and Latin America. Half the population of the developing world will live in cities by the end of this century. Disposal of urban waste, particularly sewage, is already a serious problem for many cities in poor countries. Further increases in urban population will simply worsen the situation. Modern sewage systems require huge capital investments, which developing countries can hardly afford. The 1.5 grams of phosphorus consumed and excreted daily by each adult city dweller are released far from the rural areas where food crops are grown. Treatment plants for the removal of phosphorus (based on physico-chemical methods) are too costly even for many industrialized nations. It is unreasonable to expect that developing countries will have adequate resources to build such tertiary treatment plants.

The major concern now is that developing countries obtain an adequate and reliable supply of phosphorus to increase their food production. Fortunately, there are alternative phosphorus sources that do not depend on imported fertilizer made from phosphate rock. Only a few nations have recoverable deposits of phosphate rock, and the supply of phosphate ore is subject to interruption for economic or political reasons.

The entire demand for phoshorus, nitrogen and potassium fertilizer could be met in most developing countries, according to a study by the Food & Agriculture Organization, by treatment and recycling of sewage and organic wastes. In fact, the use of cowdung and crop residues as fertilizer dates to antiquity. Farmers in many developing countries still rely on these nutrient sources, but present methods are inefficient and could probably be improved substantially by scientific study. The most productive utilization of these potential resources requires the development of appropriate technology. Many interesting possibilities exist, ranging from direct use of sewage to biogasification. These methods are unlikely to be adopted on a wide scale in industrialized countries, which will continue to import large amounts of fertilizer made from mined phosphate rock. Most developing countries face an entirely different situation. As they cannot afford to buy more phosphate fertilizer, they should pursue the development of indigenous sources with great urgency.

The application of sewage, agricultural and industrial waste directly to crop fields will minimize the discharge of phosphorus to the water environment. Phosphorus is too precious a resource to be dissipated in the environment with organic waste, with adverse ecological consequences. For the sake of conservation of diminishing phosphate resources and for protection of the water environment, phosphorus must be kept within a closed cycle. Phosphorus recycling is the appropriate path for developing countries.



Release of phosphorus to the environment is the primary cause of eutrophication, leading to uncontrolled growth of aquatic plants such as the filamentous algae shown here. Environmental damage to natural waterways caused by phosphate emissions is only one reason for recovering and recycling the element; the other is the acute need for phosphate as a nutrient in agriculture *(photograph courtesy of the Weed Research Organization, UK).*

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1981

MOLECULAR SPECTROSCOPY
September 7 - 11 15th European Congress on Molecular Spectroscopy. Norwich, UK.
(Prof. W. J. Orville-Thomas, Department of Chemistry & Applied Chemistry, University of Salford, Salford M5 4WT, UK)

WATER RESOURCES MANAGEMENT
September 7 - 11 International Symposium on Water Resources Management in Industrial Areas. Lisbon, Portugal.
(L. Veiga da Cunha, Chairman of the Executive Committee, International Symposium on WRMIA, APRH — c/o LNEC, Av. do Brasil, 101, 1799 Lisbon Codex, Portugal)

COMPUTER CONTROL OF CHEMICAL PLANTS
September 8 - 11 14th European Symposium on Computerized Control and Operation of Chemical Plants. Laxenburg, (near Vienna), Austria.
(CHEM CONTROL 81, c/o Verein Osterreichischer Chemiker, Eschenbachgasse 9, A-1010 Wien, Austria)

OLEFIN METATHESIS
September 9 - 11 4th International Symposium on Olefin Metathesis. Belfast, UK.
(Prof. K. J. Ivin, Department of Chemistry, The Queen's University of Belfast, Belfast BT9 5AG, UK)

RADIOPHARMACOLOGY
September 9 - 11 2nd Int. Symposium on Radiopharmacology. Chicago, Illinois, USA.
(Pharmacology Department, School of Medicine, Loyola University, Maywood, Illinois 60653, USA)

ATMOSPHERIC CHEMISTRY
Sept 10 - Oct 10 Chemistry of the unpolluted and polluted Troposphere. Corfu, Greece.
(Dr. W. Jaeschke, Center of Environmental Protection, University of Frankfurt, Robert Mayer Strasse 11, D-6000 Frankfurt, Federal Republic of Germany)

ACTINIDES
September 10 - 15 International Conference on Actinides. Pacific Grove, California, USA.
(Dr. Norman Edelstein, Materials and Molecular Research Division, Building 70 A, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720, USA)

BUILDING MATERIALS
September 14 - 16 2nd International Conference on the Durability of Building Materials and Components. NBS Laboratories, Gaithersburg, Maryland, USA.
(G. Frohnsdorff, B-348 Building Research, National Bureau of Standards, Washington, USA)

MICROSCOPY OF COALS
September 14 - 16 Microscopy of Coals, Cokes, Carbon & Graphite. York, UK.
(Administrator, Royal Microscopical Society, 37/38, St. Clements, Oxford 0X4 1AJ, UK)

PLASTICS TECHNOLOGY
September 14 - 16 Int. Conference on Development in Polymer Science and Plastics Technology. Coventry, UK.
(Plastics and Rubber Institute, 11, Hobart Place, London SW1W OHL, UK)

SURFACE SCIENCE
September 14 - 16 4th European Conference on Surface Science. Munster, West Germany.
(ECOSS IV, Professor Dr. A. Benninghoven, Physikalisches Institut, Universität Münster, Domagkstrasse, 4400 Münster, West Germany)

ADHESION & LUBRICATION
September 14 - 18 34th International meeting of the Société de Chimie Physique on Microscopic Aspects of Adhesion & Lubrication. Paris, France.
(Société De Chimie Physique, 34th Inter. Meeting, Attn. Dr. C. Troyanowsky, Gen. Secretary, 10, rue Vauquelin, F 75005 Paris, France)

CHEMICAL ENGINEERING EDUCATION
September 15 - 17 International Symposium on Chemical Engineering Education. London, UK.
(Dr. M. D. Robinson, The Institution of Chemical Engineers, 165-171 Railway Terrace, Rugby CV21 3QH, UK)

HEAVY METALS
September 15 - 18 International Conference on Heavy Metals in the Environment. Amsterdam, The Netherlands.
(CEP Consultants, 26, Albany Street, Edinburgh EH 1 3QH, UK)

GLYCOCONJUGATES
September 21 - 25 6th International Symposium on Glycoconjugates. Tokyo, Japan.
(Prof. T. Osawa, Division of Chemical Toxicology and Immunochemistry, Department of Pharmacy, University of Tokyo, 7-3-1 Hongo, Bunkyo-Ku, Tokyo 113, Japan)

THIN FILMS
September 21 - 25 5th International thin films congress — Properties and Devices. Israel.
(Dr. Y. Shapira, School of Engineering, Tel-Aviv University, Ramat Aviv, Israel)

BIOLOGICALLY-ACTIVE NATURAL PRODUCTS
September 21 - 26 1st International Conference on Chemistry and Biotechnology of Biologically Active Natural Products. Varna, Bulgaria.
(Dr. R. Vlahov, Centre of Phytochemistry and Chemistry of Natural Products, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria)

MACROMOLECULAR PHYSICS
September 21 - 26 12th Europhysics Conference on Macromolecular Physics. Leipzig, German Democratic Republic.
(Organizing Committee, 12th EPS Conference, Karl-Marx-Universität Sektion Physik, Linnestrasse 5, DDR-7010 Leipzig, Democratic Republic of Germany)

CONFERENCES 1981

CHEMISTRY & AGRICULTURE
September 22 - 24 la chimie l'agriculture et la faim dans le monde''. Lyon, France.
(Dr. Pradal, Chargé de nussuib recherche, INSA bâtiment 209, 20 avenue Albert Einstein, 69621 Villeurbanne Cedex, Lyon, France)

MASS SPECTROMETRY
September 23 - 25 Congress of Pure and Applied Mass Spectrometry. Toulouse, France.
(J. C. Promé, Centre de Recherche de Biochimie et Génétique Cellulaires, 118, Route de Narbonne, 31062 Toulouse Cedex, France)

WATER TREATMENT
September 24 - 25 Water People and Waste: The 7th Water and Waste Engineering for Developing Countries Conference. Loughborough, UK.
(Mr. John Pickford, WEDC, Department of Civil Engineering, University of Technology, Loughborough, UK)

INDUSTRIAL CRYSTALLIZATION
September 28 - 30 8th Symposium on Industrial Crystallization. Budapest, Hungary.
(Dr. M. Preisich, Magyar Kemikusok Egyesülete, Anker Köz 1, H-1061, Budapest VI, Hungary)

POWDER TECHNOLOGY
September 28 - 30 International Symposium on Powder Technology'81. Kyoto, Japan.
(The Society of Powder Technology Japan, c/o Shibunkaku Kaikan Sekidencho, Tanka, Sakyo-ku, Kyoto 606, Japan)

RADIOISOTOPES
Sept 28 - Oct 2 International Conference on Industrial Applications of Radioisotopes and Radiation Technology. Grenoble, France.
(Mr. Robert Najar, Conference Service Section, IAEA, PO Box 100, A-1400, Vienna, Austria)

CHEMICAL PHYSICS
Sept 28 - Oct 4 Int. Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-b, SU-117334 Moscow, USSR)

BIO-CALORIMETRY
Sept/Oct International Symposium on Bio-Calorimetry. Tbilisi, Georgian SSR, USSR.
(Dr. P. G. Asatiani, Institute of Physics, Acad. Sci. GSSR, Guramishvili str. 6, 380077 Tbilisi, USSR)

CLINICAL PHARMACOLOGY
October 11th International Symposium on Clinical Pharmacology. Pisa, Italy.
(Prof. Dr. A. Bertelli, Via Roma 55, I-56100 Pisa, Italy)

CHEMICAL ENGINEERING
October 4 - 9 2nd World Congress of Chemical Engineering. Montreal, Canada.
(Canadian Society for Chemical Engineering, 151 Slater St., Suite 906, Ottawa, Ontario, Canada K1P 5H3)

EUTROPHICATION & WATER SUPPLY
October 4 - 9 International Water Supply Association Specialized Conference on Eutrophication and Water Supply. Rabat, Morocco.
(Organization Committee of the Specialized Conference, RABAT IWSA, c/o Setude, 27 Boulevard des Italiens, F-75002, Paris, France)

WATER POLLUTION CONTROL
October 4 - 10 Water Pollution Control Federation Int. Convention. Detroit, Michigan, USA.
(R. A. Canham, 3900 Wisconsin Avenue, NW, Washington DC 20016, USA)

PROCESS CONTROL
October 6 - 7 International Conference on Control of Industrial Processes. Milan, Italy.
(Federazione delle Associazioni Scientifiche e Tecniche, P le R Morandi 2, 20121 Milano, Italy)

ENERGY/ASIA
October 7 - 9 Ascope 81: 2nd Asian Energy Conference. Manila, Philippines.
(ASCOPE 81, PNOC Building, 7901 Makati Avenue, Makati, Philippines)

ACTINIDES
October 12 - 16 International Meeting on Radiobiology of Radium and the Actinides in Man. Lake Geneva, Wisc, USA.
(Dr. J. Rundo, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439, USA)

NUCLEAR TECHNOLOGY
October 12 - 16 International Conference on Nuclear Technology in Developing countries; problems and prospects. Trieste, Italy.
(Conference Coordinator, Arab Development Institute, POB 5300, 14 Beirut, Lebanon)

MATERIALS FOR COAL CONVERSION
October 13 - 15 6th Annual Conference on Materials for Coal Conversion and Utilization. NBS Laboratories, Gaithersburg, Maryland, USA.
(S. J. Schneider, B-308 Materials Building, National Bureau of Standards, Washington DC USA)

BIOMEDICAL RESEARCH
October 19 - 21 2nd International Symposium on Spectroscopic Methods for Biomedical Research. Battelle-Columbus, Ohio, USA.
(Karen L. Waite, Battelle's Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201, USA)

MATERIALS & ENERGY FROM REFUSE
October 20 - 22 2nd International Symposium on Materials and Energy from Refuse. Antwerp, Belgium.
(KVIV, Ingenieurshuis, Jan van Rijswijcklaan 58, B-2000, Antwerp, Belgium)

CHEMASIA 81
October 21 - 24 2nd Asian International Chemical Process Engineering & Contracting Show & Conference. World Trade Centre, Singapore.
(John Huang, Singapore Exhibition Service (pte) Ltd. 410 Cathay Building, Mount Sophia, Singapore 0922)

GENERAL CHEMISTRY EDUCATION
November Conference on Teaching of General Chemistry. Bandung, Indonesia.
(Dr. S. Radhakrishna, Secretary of Committee on Science & Technology in Developing Countries (COSTED), Indian Institute of Science, Bangalore 560012, India)

MAGNETOHYDRODYNAMICS
November 4 - 6 Int. Conference on Magnetohydrodynamics. Sydney, Australia.
(Conference Manager, The Institute of Engineers Australia, 11 National Circuit, Barton, ACT 2600, Australia)

TECHNOLOGY FOR DEVELOPMENT
November 6 - 13 2nd World Technology Fair for Developing Countries, "Technology for the People."Mexico City.
(The Fair Director, World Trade Center, Case Postale 187, 1215 Geneva 15, Switzerland)

MICROBIOLOGY & TOXICOLOGY
November 9 - 11 Symposium on Microbiology and Toxicology. Bristol, UK.
(Society of Cosmetic Scientists, 56 Kingsway, London WC2B 6DX, UK)

FUEL CYCLES
November 9 - 12 International Conference on Fast Reactor Fuel Cycles. London, UK.
(The Secretariat, British Nuclear Energy Society at the Institution of Civil Engineers, 1 - 7 Great George Street, Westminster, London SW1P 3AA, UK)

ENVIRONMENTAL POLLUTION
November 16 - 17 2nd International Symposium on Environmental Pollution. Miami Beach, Florida, USA.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

CHROMATOGRAPHY
November 19 - 20 2nd International Chromatography Conference. Miami Beach, Florida, USA.
(Mr. V. M. Bhatnagar, Alena Enterprises of Canada, PO Box 1779, Cornwall, Ontario, Canada K6H 5V7)

ENVIRONMENTAL POLLUTION
November 22 - 25 International Association of Water Pollution Research Specialized Conference on Micropollutants in the Environment. Brussels, Belgium.
(Secretariat, Specialized IAWPR Conference, Centre International de Conferences de Bruxelles, Parc des Expositions, B-1020 Brussels, Belgium)

CHEMICAL ANALYSIS OF POLLUTANTS
November 23 - 27 2nd International Congress on Analytical Techniques in Environmental Chemistry and Workshop on the Chemistry and Analysis of Hydrocarbons in the Environment. Barcelona, Spain.
(Congress on Analytical Techniques in Environmental Chemistry Expoquimia, Plaza de Espana, Barcelona 4, Spain)

FOOD IRRADIATION
November 24 - 28 UNFAO/IAEA International Symposium on Combination Processes in Food Irradiation. Colombo, Sri Lanka.
(UNFAO/IAEA Int. Symposium, P.O. Box 100, Vienna International Centre, A-1400 Vienna, Austria)

CHEMICAL ENGINEERING
November 25 - 27 2nd Mediterranean Congress on Chemical Engineering. Barcelona, Spain.
(2° Congreso Mediteraneo De Ingenieria Quimica Expoquimia-81 / Congress Secretariat, Plaza Espana, Barcelona-4, Spain)

SCIENTIFIC COMMUNICATION
Nov/Dec Meeting on Communication of Science Information. Jakarta, Indonesia.
(Dr. S. Radhakrishna, Secretary of Committee on Science & Technology in Developing Countries (COSTED), Indian Institute of Science, Bangalore 560012, India)

ENVIRONMENTAL POLLUTION
December 17 - 18 2nd European Conference on Environmental Pollution. Linz, Austria.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

1982

CHEMICAL FEEDSTOCKS FROM COAL
February Int. Symposium "Chem-Coal — A Chemical Feedstock. Johannesburg, South Africa.
(Mr. F. L. D. Cloete, South African Inst. of Chemical Engineers, c/o CERG-CSIR, P.O. Box 395, Pretoria 0001, South Africa)

CHEMISTRY RELATING TO AGRICULTURE
February 2 - 5 Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington DC 20036, USA)

ESR OF ORGANIC RADICALS
March 22 - 26 International Conference on Electron Spin Resonance of Organic and Bio-Organic Radicals. Nottingham, UK.
(Dr. J. B. Raynor, Chemistry Department, The University, Leicester LE1 7RH, UK)

SAFE USE OF SOLVENTS
March 23 - 27 Int. Symposium on the Safe Use of Solvents. Brighton, UK.
(Secretariat, International Symposium on the Safe Use of Solvents, 142 - 144, Oxford Road, Cowley 0X4 2DZ, UK)

ELECTROLYTES IN MIXED SOLVENTS
March 28 - April 2 International symposium on "Thermodynamic Behavior of Electrolytes in Mixed Solvents" to be held at the American Chemical Society 183rd National Meeting. Las Vegas, Nevada, USA.
(William F. Furter, Professor of Chemical Engineering, Royal Military College of Canada, Kingston, Ontario, Canada K7L 2W3)

AMERICAN CHEMICAL SOCIETY
March 29 - April 2 183rd American Chemical Society National Meeting. Las Vegas, Nevada, USA.
(American Chemical Society, 1155 16th Street, NW, Washington DC 20036, USA)

UK CHEMICAL CONGRESS
March 30 - April 1 Annual Chemical Congress. Birmingham, UK.
(Chemical Society, Burlington House, London W1V 0BN, UK)

ANALYSIS OF POLLUTANTS
April 14 - 16 12th Annual Symposium on the Analytical Chemistry of Pollutants. Amsterdam, The Netherlands.
(Congress Bureau Vrije Universiteit, P. O. Box 7161, 1007 MC Amsterdam, The Netherlands)

CLINICAL CHEMISTRY
April 19 - 22 International Congress on Automation in Clinical Laboratory. Barcelona, Spain.
(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clinicos, C.S. "Príncipes de Espana", Hopitalet de Llobregat (Barcelona), Spain)

CONFERENCES 1982

TRACE ELEMENT ANALYSIS
April 21 - 23 2nd International Workshop on Trace Element Analytical Chemistry in Medicine and Biology. Neuhrberg, Federal Republic of Germany.
(Dr. P. Schramel, Gesellschaft für Strah en- und Umweltforschung für Angewandte Physik, Physikalisch-Technische Abteilung, Ingolstäder Landstrabe 1, D-8042 Neuherberg, Federal Republic of Germany)

RADICAL POLYMERISATION
May Microsymposium on Radical Polymerisation. Smolenice, Czechoslovakia.
(Dr. E. Borsig, Institute of Polymer Chemistry, SAV, Dúbravska cesta, Bratislava, Czechoslovakia)

SCIENCE/SOUTH PACIFIC
May 52nd Conference of the Australian & New Zealand Association for the Advancement of Science. Sydney, Australia.
(ANZAAS, Box 873, GPO Sydney 2001, Australia)

GEOCHEMICAL EXPLORATION
May 12 - 14 9th Int. Geochemical Exploration Symposium. Saskatchewan, Canada
(V. Sopuck, Saskatchewan Research Council, 30, Campus Drive, Saskatoon, Saskatchewan S7N 0X1, Canada)

FOOD PROCESSING
May 15 - 20 Food Conference 1982, Singapore.
(The Conference Secretariat, Food Conference 1982, Singapore Professional Centre, Block 23, 129-B, Outram Park, Singapore 0316)

COMPUTERS IN CHEMICAL ENGINEERING
May 25 - 27 CHEMCOMP 82: Symposium on Chemical Process Analysis and Design using Computers. Antwerp, Belgium.
(Symposium CHEMCOMP 82, c/o K.VIV, Jan Van Rijswijcklaan 58, B-2000, Antwerp, Belgium)

CATALYSIS
May 26 - 29 8th Canadian Symposium on Catalysis. Waterloo, Ontario, Canada.
(Jana Karger, Symposium Secretary, 8th Canadian Symposium on Catalysis, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1)

ZIRCONIUM
June 6th International Conference on Zirconium. Vancouver, Canada.
(Meetings Department, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA)

CHEMICAL ENGINEERING
June 6 - 12 20th Chemical Engineering Exhibition Congress and the International Meeting of Chemical Engineering.
(ACHEMA 82): Chemical engineering, corrosion and biotechnology. Frankfurt am Main, Federal Republic of Germany.
(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt am Main, Federal Republic of Germany)

INDUSTRIAL MICROORGANISMS
June 7 - 11 4th International Symposium on the Genetics of Industrial Microorganisms. Kyoto, Japan.
(GIM Japan National Committee, c/o Microbiology Research Foundation, 2-4-16 Yayoi, Bunkyo-Ku, Tokyo 113, Japan)

QUANTUM CHEMISTRY
June 14 - 19 4th International Congress in Quantum Chemistry, Uppsala, Sweden.
(Uppsala Quantum Chemistry Group, Box 518, S-751 20 Uppsala, Sweden)

POLYMER LATEX & EMULSIONS
June 15 - 17 International Conference on Polymer Latex and Emulsions. London, UK.
(Mr. R. H. Craven, Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, UK)

MEDICINAL CHEMISTRY
June 20 - 24 Medicinal Chemistry Symposium. Toronto, Canada.
(Leslie Humber, North American Medicinal Chemistry Symposium, c/o Ayerst Laboratories, P.O. Box 6115, Montreal, Quebec, H3C 3J1, Canada)

SOLUTE - SOLVENT INTERACTIONS
July 4 - 10 6th International Symposium on Solute - Solute-Solvent Interactions. Minoo, Osaka Prefecture, Japan.
(Prof. Hitoshi Ohtaki (Department of Electronic Chemistry, Tokyo Institute of Technology at Nagatsuta, Nagatsuta-cho, Midori-ku, Yokohama, 227 Japan)

REACTION MECHANISMS IN SOLUTION
July 5 - 9 3rd International Conference on Mechanisms of Reactions in Solution. Canterbury, UK.
(Dr. John F. Gibson, Secretary (Scientific), The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK)

PHYSICAL ORGANIC CHEMISTRY
July 11 - 16 6th IUPAC Conference on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Universite Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, B-1348 Louvain-la-Neuve Belgium)

CHITIN AND CHITOSAN
July 12 - 14 2nd International Conference on Chitin and Chitosan. Sapporo, Japan.
(Dr. S. Hirano, Department of Agricultural Biochemistry, Tottori University, Tottori 680, Japan)

MACROMOLECULES
July 12 - 16 IUPAC Macromolecular Symposium. Amherst, Massachusetts, USA.
(James C. W. Chien, Dept. of Polymer Science and Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA)

SELECTIVE POLYMER SORBENTS
July 19 - 22 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.
(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 162 06 Prague 616, Czechoslovakia)

NON-AQUEOUS SOLUTIONS
July 19 - 23 8th International Conference on Non-aqueous solutions, Nantes, France.
(Pham Van Huong, Laboratoire de Spectroscopie Infrarouge et Raman, Universite de Bordeaux I. 351 Cours de la Liberation - 33405, Talence, France)

MARINE NATURAL PRODUCTS
July 26 - 30 4th International Symposium on Marine Natural Products. Tenerife, Canary Islands, Spain.
(Prof. A. G. Gonzalez, Department of Organic Chemistry, University of La Laguna, Tenerife, Spain)

CONFERENCES 1982

ATOMIC SPECTROSCOPY
July 27 - 30 14th Conference of the European Group for Atomic Spectroscopy. Liége, Belgium.
(Mr. N. Grevesse, BFS-Group, University of Liège, Sart Tilman B15, B-4000, Liège, Belgium)

NATURAL PRODUCTS
August 2 - 7 13th Int. symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs. Jeanne Beck, Symposium Secretariat - S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa)

MARINE CHEMISTRY
August 2 - 13 Joint Oceanographic Assembly. Halifax, Canada.
(Mr. Leo O'Quinn, Executive Secretary, JOA-82, 240 Sparks Street, 7th Floor West, Ottawa, Ontario, K1A 0E6, Canada)

BIOCHEMISTRY
August 15 - 21 12th Int. Congress of Biochemistry. Perth, Australia.
(Prof. B. N. Preston, Biochemistry Dept., Monash University, Clayton, Victoria 3168, Australia)

COAL CONVERSION
August 16 - 20 International Coal Conversion Conference. Pretoria, South Africa.
(The Symposium Secretariat S.244, International Coal Conversion Conference, Council for Scientific and Industrial Research, P.O. Box 395, 0001 Pretoria, Republic of South Africa)

CRYSTALLOGRAPHY
August 16 - 25 12th General Assembly and Int. Congress on Crystallography. Ottawa, Canada.
(Dr. J. N. King, IUcr Secretariat, 5 Abbey Sq., Chester CH1 2HU, UK)

PLANETARY ATMOSPHERES
August 17 - 28 International Conference on Origin and Evolution of Planetary Atmospheres. Hamburg, Federal Republic of Germany.
(Mr. S. Ruttenberg, Int. Assoc. of Meteorology & Atmospheric Physics Secretariat, NCAR. P.O. Box 3000, Boulder, CO 80307, USA)

ORGANIC SYNTHESIS
August 22 - 27 4th International Conference on Organic Synthesis. Tokyo, Japan.
(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan)

THERMAL ANALYSIS
August 22 - 28 7th International Conference on Thermal Analysis. Kingston, Ontario, Canada.
(Chairman, Organizing Committee, seventh ICTA, Dunlop Research Centre, Sheridan Park Research Community, Mississauga, Ontario, Canada L5K 1Z8)

CHEMISTRY/AUSTRALIA
August 23 - 27 7th National Convention of the Royal Australian Chemical Institute, Canberra, Australia.
(Dr. J. H. Bradbury, Chairman, 7NC, Chemistry Department, Australian National University, Canberra, A.C.T. Australia)

COORDINATION CHEMISTRY
August 23 - 27 22nd Int. Conference on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010 Hungary)

GAS KINETICS
August 23 - 27 7th International Symposium on Gas Kinetics. Gottingen, West Germany.
(Prof. J. Troe, Institut für Physikalische Chemie der Universität Göttingen, Tammanstrasse 6, 3400 Göttingen, Federal Republic of Germany)

CHEMICAL ENGINEERING
August 24 - 26 10th Australasian Conference on Chemical Engineering - CHEMECA '82. Sydney, Australia.
(The Conference Manager, The Institution of Engineers, Australia, 11 National Circuit, Barton ACT 2600, Australia)

POLYMER STRUCTURE & PROPERTIES
Aug 29 - Sept 2 Sympsoium on the Interrelations between Processing, Structure & Properties of Polymeric Materials. Athens, Greece.
(Prof. P. S. Theocaris, Chair of Applied Mechanics, National Technical University of Athens, Athens, Greece)

PESTICIDE CHEMISTRY
Aug 29 - Sept 4 5th Int. Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan)

PLANT GROWTH
Aug 29 - Sept 4 21st International Horticultural Congress. Hamburg, Federal Republic of Germany.
(21st International Horticultural Congress, Hamburg Messe und Congress GmbH, P.O. Box 30 23 60, D-2000 Hamburg 36, Federal Republic of Germany)

MASS SPECTROMETRY
Aug 30 - Sept 3 9th Int. Mass Spectrometry Conference. Vienna, Austria.
(INTERCONVENTION, P.O. Box 80, A-1107 Vienna, Austria)

MYCOTOXINS AND PHYCOTOXINS
Aug 31 - Sept 2 5th Int. Symposium (IUPAC) on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30[2], DK-2100 Copenhagen Ø, Denmark)

TRANSIENT SPECIES
Autumn Euchem Conf. on Short lived species in inorganic chemistry and their stabilizaton. Federal Republic of Germany.
(GDCh-Geschäftsstelle, Postfach 90 04 40, 6000 Frankfurt/Main 90, Federal Republic of Germany)

IONIZED GASES
September 6th Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases (ESCAMPIG) Oxford, UK.
(Dr. R. W. P. McWhirter, Rutherford Laboratory, Chilton, Didcot 0X11 0QX, UK)

THEORETICAL CHEMISTRY
September International Symposium on Theoretical Organic Chemistry. Dubrovnik, Croatia, Yugoslavia.
(Dr. Ante Graovac, Institute "R. Bošković", POB 1016, 41001 Zagreb, Yugoslavia)

CHEMICAL STRUCTURE - BIOLOGICAL ACTIVITY
September 6 - 9 4th European Symposium on Chemical Structure and Biological Activity: Quantitative Approaches. Bath, UK.
(Dr. J. C. Dearden, School of Pharmacy, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF, UK)

PREPARATION OF HETEROGENEOUS CATALYSTS
September 6 - 9 3rd Int. Symposium on the Scientific Bases for the Preparation of Heterogeneous Catalysts. Louvain-la-Neuve, Belgium.
(Prof. B. Delmon, Université Catholique de Louvain, Groupe de Physico-Chimie Minerale et de Catalyse Place Croix du Sud 1, B-1348 Louvain-la -Neuve, Belgium)

HEAT TRANSFER
September 6 - 10 7th International Heat Transfer Conference. München, Federal Republic of Germany.
(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt, Federal Republic of Germany)

RAMAN SPECTROSCOPY
September 6 - 12 8th International Conference on Raman Spectroscopy. Bordeaux, France.
(Prof. J. Lascombe, Université de Bordeaux 1, 351, cours de la Libération, 33405 Talence Cedex, France)

CHEMICAL THERMODYNAMICS
September 7 - 10 7th International Conference on Chemical Thermodynamics. London, UK
(Prof. M. L. McGlashan, Department of Chemistry, University of College London, 20 Gordon Street, London WC1H OAJ, UK)

AMERICAN CHEMICAL SOCIETY
September 12 - 17 184th National Meeting of the American Chemical Society. Kansas City, Missouri, USA.
(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA)

THERMODYNAMICS-CALORIMETRY
September 13 - 17 2nd Czechoslovak Conference on Calorimetry. Liblice and Prague, Czechoslovakia.
(Prof. Dr. Ing, Jiří Pick, Dr Sc. Dept. of Physical Chemistry, Institut of Chemical Technology, 166 28 Prague 6, Suchbatarova 5, Czechoslovakia)

WATER POLLUTION
October Water Pollution Control Federation Int. Convention. Saint Louis, Missouri, USA.
(R. A. Canham, 3900 Wisconsin Avenue NW, Washington DC 20016, USA)

CHEMICAL REACTION ENGINEERING
October 4 - 6 International Symposium "Chemical Reaction Engineering". Boston, Massachusetts, USA.
(Prof. James Wei, Dept. of Chemical Engr., Mass. Inst. of Tech., Cambridge, MA 02139, USA)

1983

AMERICAN CHEMICAL SOCIETY
March 20 - 25 185th ACS National Meeting. Seattle, USA.
(A. T. Winstead, ACS, 1155 - 16th St. N.W., Washington, DC 20036, USA)

SCIENCE/SOUTH PACIFIC
May 53rd Conference of the Australian & New Zealand Association for the Advancement of Science. Perth, Australia.
(ANZAAS, Box 873, GPO, Sydney 2001, Australia)

SMOKING AND HEALTH
July 10 - 15 5th World Conference on Smoking and Health. Winnipeg, Canada.
(5th World Conference on Smoking and Health, P.O. Box 228, Station B, Ottawa, Ontario, Canada K1P 6C4)

ANALYTICAL CHEMISTRY
July 17- 23 SAC 83 Conference and Exhibition, organised by the Analytical Division of the Royal Society of Chemistry. University of Edinburgh, Edinburgh, UK.
(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, UK)

PERMAFROST
July 18 - 22 4th International Conference on Permafrost. Fairbanks, Alaska, USA.
(Louis De Goes, Executive Secretary, Polar Research Board, National Academy of Sciences, 2101 Constitution Ave., N.W. Washington DC 20418, USA)

IUPAC GENERAL ASSEMBLY
August 18 - 26 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.
(IUPAC Secretariat, 2 - 3, Pound Way, Cowley Centre, Oxford 0X4 3YF, UK)

AMERICAN CHEMICAL SOCIETY
Aug 28 - Sept 2 186th National Meeting of the American Chemical Society, Washington D.C. USA.
(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA)

TRACE ANALYSIS
Aug 28 - Sept 2 Int. Symposium on Micro-chemistry techniques and trace analysis. Amsterdam.
(Dr. W. J. van Oort, c/o Municipal Congress Bureau, O.Z. Achterburgwal 199, 1012 DK Amsterdam, Netherlands)

AGRICULTURAL PATHOGENS
Aug. 28 - Sept 3 3rd International Mycological Congress. Tokyo, Japan,
(Prof. K. Tsubaki, Institute of Biological Sciences, The University of Tsukuba, Sakurma-mura, Ibraki, Pref. 305, Japan)

POLYMERIZATION OF HETEROCYCLES
September Int. Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.
(Prof. Z. Jedliński, Polish Academy of Sciences, Polymer Institute, POB 49, Curie - Sklodowskiej 34, PL - 41 800 Zabrze, Poland)

GEOCHEMICAL EXPLORATION
September 10th International Geochemical Exploration Symposium. Helsinki, Finland.
(L. K. Kauranne. Organizing Committee, 10th IGES., The Geological Survey of Finland, Kivimiehentie 1, 02150 Espoo 15, Finland)

MACROMOLECULES
September 5 - 9 29th International Symposium on Macromolecules. Bucharest, Romania.
(Acad. Cristofor Simionescu, Institutul de Chimie Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr. 41A, Lasi, Romania)

WORLD ENERGY
September 19 - 23 12th World Energy Conference. New Delhi, India.
(E. Ruttley, World Energy Conference, 34 St. James' Street, London SW1A 1HD, UK)

Chemistry International

is the news magazine of the

INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY (IUPAC)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

NATIONAL MEMBER ORGANIZATIONS

Academy of Scientific Research and Technology **(Arab Republic of Egypt)**
Asociación Química Argentina **(Argentina)**
Australian Academy of Science **(Australia)**
Verein Österreichischer Chemiker **(Austria)**
Comité National Belge de Chimie **(Belgium)**
Associação Brasileira de Química **(Brazil)**
Bulgarian Academy of Sciences **(Bulgaria)**
National Research Council of Canada **(Canada)**
Chinese Chemical Society, and Chemical Society located in Taipei, China **(China)**
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Comité National Français de la Chimie **(France)**
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Chemistry International

IUPAC

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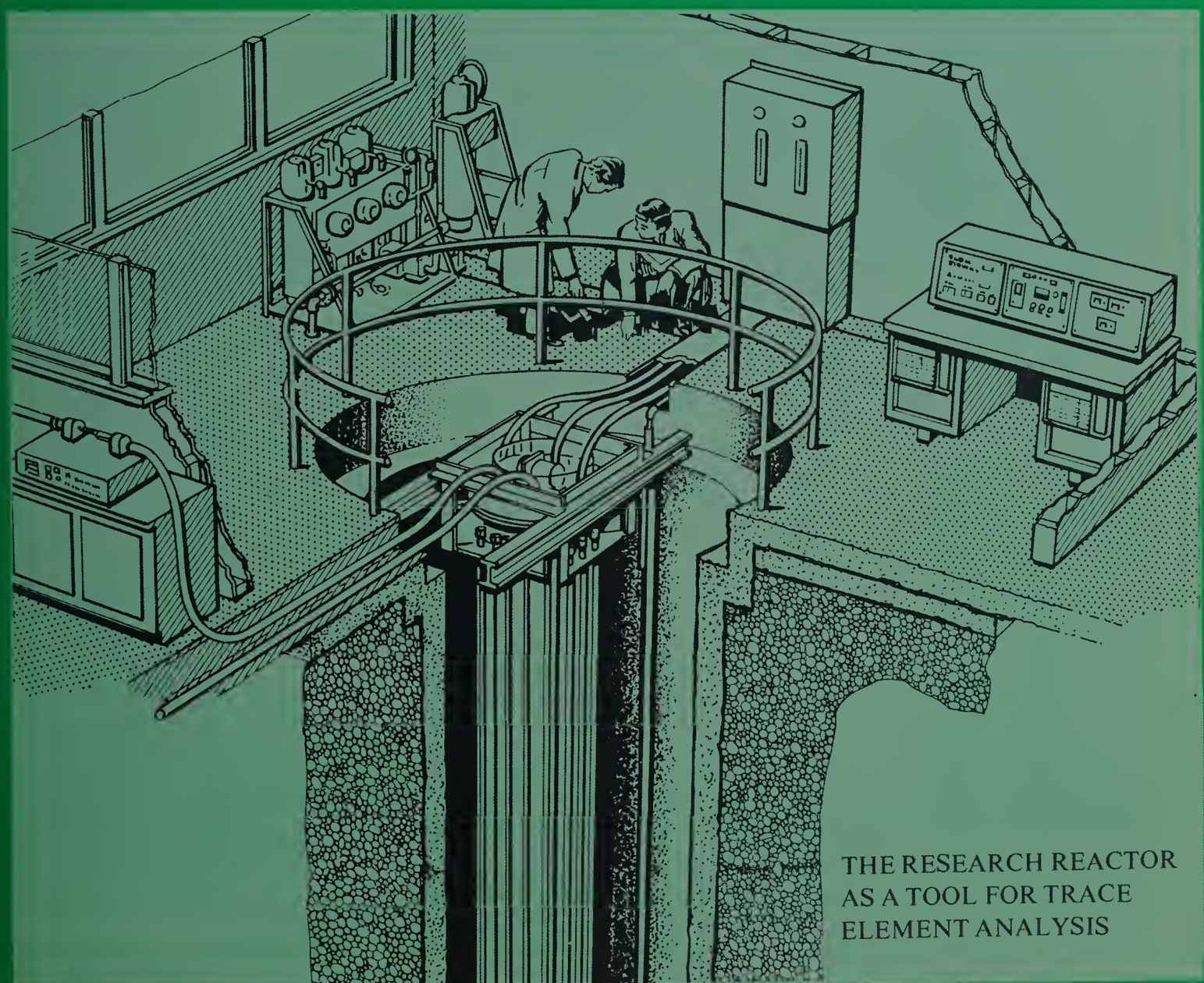

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1981 No.5 (October)

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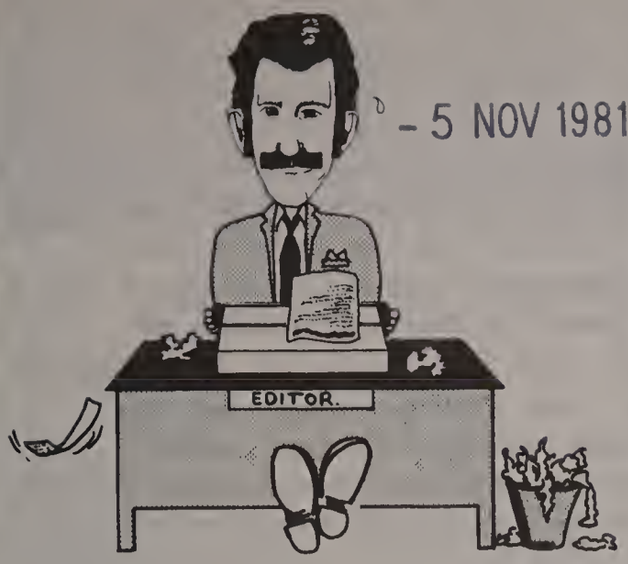

THE EDITOR'S DESK

Opinions expressed here are those of the author, and do not necessarily reflect the views or policy of IUPAC.

IUPAC should focus its resources on fewer projects to meet major needs of the chemical community, Prof. Zollinger recommends at General Assembly

As has been traditional at all IUPAC General Assemblies, President Zollinger will open the meeting of the IUPAC Council (which consists of representatives of IUPAC's 44 member organizations) to conclude the 31st IUPAC General Assembly, held August 25th—September 2nd.

The President's recommendations have a strong influence on the decisions of the Council, although the power to implement or reject them lies with the Council.

We received an advance copy of Prof. Zollinger's address to the IUPAC Council shortly before this issue went to press. In it, Prof. Zollinger recommended that IUPAC Commissions concentrate their efforts on those projects having greatest importance and impact. He also proposed that five Commissions be dissolved, or their activities suspended until a specific programme of more constructive projects can be presented.

President Zollinger's proposals were based upon an extensive evaluation of projects undertaken by IUPAC during the last 7—8 years. For this assessment, Prof. Zollinger, Vice-President Nagakura and Secretary-General Ourisson examined annual reports of IUPAC Divisions, Commissions and Committees, each Commission's published reports and their listings of current projects. Published reports were also evaluated independently by industrial chemists in seven countries from IUPAC's Committee on Chemistry and Industry. The three IUPAC officers then discussed their initial impressions with the President of each IUPAC Division. In cases where the evaluators received negative responses, they consulted independent experts with an international reputation in the respective subject areas.

The evaluation had been prompted by the IUPAC Council decision two years ago (at the 1979 General Assembly in Davos, Switzerland) to reduce IUPAC expenditures in 1981 by US$100 000. After numerous informal discussions, Prof. Zollinger had concluded that this Council decision was not simply financial in nature, but reflected a dissatisfaction with inefficiency with which projects were undertaken, the excessively long periods which elapsed before projects were completed, inadequate re-orientation of IUPAC resources towards solving new and pressing problems, and involvement of too few chemists in IUPAC work.

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The primary goal of the intensive evaluation of IUPAC projects, Prof. Zollinger emphasized, was not simply to improve the financial position of IUPAC, but to increase the quality of its work, the efficiency with which it is carried out, and to maintain the IUPAC label as a hallmark of scientific and technological quality. He is convinced that IUPAC would be in a better position to obtain financial support from its national member organizations, Company Associates and international organizations (such as UNESCO) if it could demonstrate convincingly that its money was spent with greater efficiency.

Presenting the findings of the evaluation, Prof. Zollinger states that "we learned that IUPAC's activities in many fields are highly regarded internationally. On the other hand, we also learned that some work holds little or no interest for chemists apart from members of the respective Commission and that other work of IUPAC is published late, often years after the time it was needed by the chemical community. . . Too many of the so-called 'current projects' were begun 5 or more years in the past and finally disappeared without comment from (annual) reports and lists (of current projects)."

"We work on too many projects with insufficient intensity", Prof. Zollinger concludes. "It is better to concentrate on a smaller number of problems, and to work on them for a shorter period of time and in a qualitatively more profound way." However, he notes that some IUPAC bodies have been extremely active, and responded to contemporary problems of great importance. As one example, Prof. Zollinger points to the Committee on Teaching of Chemistry, whose members have directed their efforts towards helping chemistry teachers in developing countries and towards improving the quality of chemistry teaching in industrialized countries. He also cited the efforts of IUPAC's CHEMRAWN (*Chemical Research Applied to World Needs*) Committee, and enthusiastically supports the convening of a second CHEMRAWN conference, dealing with Chemistry and World Food Supplies, to be held in December 1982 in the Philippines.

In order to open IUPAC to wider participation by chemists throughout the world, Prof. Zollinger endorses a plan that would allow individual chemists to become IUPAC "affiliate" members through their national science academies or chemical societies, and to invite Presidents of national chemical societies to meet informally at IUPAC General Assemblies. He also urges that IUPAC develop closer relations with the World Health Organization (WHO), the United Nations Educational Scientific & Cultural Organization (UNESCO), and the new International Organization of Chemical Sciences in Development (IOCD).

Dr. Martin Gellender

Lab workers cannot rely on toxicity data to avoid exposure to dangerous chemicals

Stringent measures are being applied to protect workers in the chemical industry in response to the growing awareness of the health hazards of long-term exposure to chemical compounds. Workers in a typical chemical plant may be exposed persistently to a few compounds over a period of many years. Until recently, the effects of chronic exposure to most industrial chemicals was unknown and given little consideration. Even now, extensive toxicity testing with laboratory animals has been performed on relatively few compounds. About two dozen compounds have definitely been shown to cause cancer in humans, and very likely, the hundreds of compounds shown to cause cancer in laboratory animals have some carcinogenic potential in man. In a few cases, exposure to one compound over a period of many years could be identified as the cause of a high cancer incidence among former chemical plant workers.

As a result, major industrial chemicals are now routinely subjected to at least preliminary screening tests to identify those likely to induce cancer or genetic mutations in exposed workers, or lead to birth defects in their children. For chemicals found to be potentially dangerous, steps are taken to decrease concentrations to which industrial workers are exposed (see, for instance, how a potential cancer epidemic among workers in the vinyl chloride industry was sighted and sunk, in *Chemistry International,* February 1981).

But what about protection of the laboratory worker? Here, an entirely different approach is required, according to a report* of the US National Research Council. Most research workers, the report points out, work with a very large number of compounds. Many are used only infrequently, and rarely is any one compound handled for an extended period. Often, new compounds may be synthesized. The toxicity of many of these compounds has not been investigated, and their ability to potentiate the toxic effects of other compounds is usually unknown. Conducting toxicity tests on all compounds used in research, or on each new compound synthesized, would be completely impractical. Furthermore, while the acute or long-term biological effects of a compound can sometimes be inferred from knowledge of its structure (see box), most often it cannot.

Rather than provide specific precautions for handling each specific compound, as is done with chemical plant workers, the National Research Council recommends that laboratory workers take steps to minimize their exposure to all compounds used in their experiments. Unless actual toxicological data is available, the report urges, all new substances should be handled as though they were toxic. By treating all unfamiliar chemicals as potential toxins, laboratory workers could very much limit their exposure to chemicals which induce cancer, or have other long-term effects. Equally important, the additional care in handling chemicals and greater use of protective equipment would reduce the risk of acute poisoning or injury caused by compounds which are highly poisonous, explosive or inflammable.

The report, *Prudent Practices for Handling Hazardous Chemicals in Laboratories,* comprises a 290-page safety handbook, with advice on general laboratory practice; procedures for handling substances that are known to be toxic, inflammable or explosive; procedures for safe handling of compressed gases; and recommendations for procurement, storage and disposal of chemicals. One chapter describes hazards associated with 33 toxic compounds commonly used in the laboratory, and precautions for their handling.

The report emphasizes safety procedures, rather than safety equipment. However, one piece of equipment — a properly maintained fume hood — is fundamental to safe laboratory operations, and can provide protection in such a wide range of laboratory procedures, as to warrant thorough discussion. In this 20 page section, the report points out that a fume hood, besides preventing toxic or flammable vapours from entering the laboratory atmosphere, imposes a physical barrier of shatterproof glass (which should be at least 5.5 mm thick) that protects laboratory workers from chemical splashes, fires and minor explosions. A hood is also an effective device for containing accidental spills. But while a fume hood can provide substantial protection against a range of hazards, it is effective only if it is properly maintained and correctly used. In many laboratories this may not be the case.

In order to maintain maximum protection from a fume hood, one must not forget that it is intended as a *back-up* safety device. Use of a fume hood does not obviate the need for good laboratory practice, a carefully-planned experiment, or an organized system for disposal of wastes. An apparatus placed within a fume

Predicted values of toxicity are unreliable and possibly dangerous, Working Party warns

A technique which is proving useful in the development of new drugs is QSAR, Quantitative Structure - Activity Relationships, in which the known biological activity of tested compounds is related to the structural features of their molecules (for example, the size, shape and electron-withdrawing effect of substituent groups; bond angles or molecular dimensions). Once a mathematical relationship is derived for a series of tested compounds, then the biological activity of an unknown compound may be estimated.

Attributing biological activity to particular structural features of a drug molecule is exactly what pharmaceutical researchers have always tried to do. However, the widespread availability of computers now allows researchers to do this in a much more sophisticated and formal way, and extend the technique to a very large number of structural factors (most of which haye not previously been thought related to biological activity). By synthesizing new compounds, whose structural features fulfil the requirements of these mathematical relationships, more potent or specific substances may be arrived at. The QSAR technique is now widely used, and many success stories have been reported (see for example, *CHEMTECH*, December 1980, pages 744 - 747). In most of these cases, the mechanism of activity of the series of biologically-active compounds is not well understood, but all the compounds presumably act in the same way — on one active site in the biological organism.

There are, however, serious limitations and perhaps even unforseen dangers associated with the QSAR technique. The main danger, as pointed out by a Working Party of the IUPC Commission on Medicinal Chemistry, is that the *predicted* activity or toxicity of a compound might be misinterpreted, and become accepted as an actual *experimental* measurement. The calculated toxicity value assigned to a compound could — after repeated quotations from the chemical literature — lose its identity as a mathematically-derived (and possibly, entirely wrong) estimate. Particularly for the calculation of toxicity, the Working Party points out, the QSAR technique may be entirely unsuited. For one thing, the toxicity of a compound may not result from one well-defined interaction with an active site. Furthermore, toxicity is often a consequence of an extensive set of complex and poorly understood interactions. A compound may exert toxic effects in a variety of ways. To assign a numerical value for toxicity (such as the compound's LD_{50}, the dose which is lethal to 50% of test animals), as is required in the QSAR method, might be unrealistic. A compound may be toxic without being lethal, or might not cause immediate observable effect.

The IUPAC Working Party on QSAR does *not* oppose all attempts to explore relationships between molecular structure and toxicity. They point to very promising recent studies, such as those performed by a group at Pennsylvania State University (USA), in which carcinogenicity in a series of compounds was predicted with an 80 - 90% success rate. But, they feel that QSAR provides meaningful estimates of toxicity only when there is a well-defined interaction between substances in a series of structually-related compounds and an active site in the biological organism. Before reaching their conclusions, the Working Party obtained expert advice from the International Union on Pharmacology, the IUPAC Commission on Toxicology, the IUPAC Commission on Chemistry and Industry, and several individual specialists. Working Party Chairman R. F. Rekker summarized the Commission's reservations about the value of QSAR toxicity estimates in an article published in *Trends in Pharmacological Sciences* (October 1980, pages 383 - 384). The article is entitled "LD_{50} Values: are they about to become predictable?". His answer, in most cases, is "no".

hood should contain condensers, traps or scrubbers if these are necessary to contain and collect waste solvents, toxic vapours or dusts. Filters should be used to collect highly toxic particles, and activated charcoal filters are recommended to absorb highly toxic gases and vapours. The hood should only be expected to contain or eliminate that material or those vapours which escape because of imperfect operation of the apparatus, or its unexpected failure.

The placement of equipment in the hood can have a dramatic effect on its performance. Moving an apparatus back from the front edge of the hood by 5 - 10 centimetres can reduce the amount of escaping vapour by 90%. A coloured stripe painted on the hood work surface (10 centimetres back from the face) provides a constant reminder that all equipment should be placed behind this boundary.

Hoods operate effectively only when there is a sufficient and uniform flow of air. A properly designed hood and ventilating system provide an air flow with an exhaust velocity of 0.3 - 0.5 metres/second. Higher air velocities (above 0.6 metres/second) is not only wasteful of energy, but is likely to create turbulence and cause vapours to spill out from within the hood to the laboratory atmosphere. Less air flow may also result in inadequate hood performance. It is important to realize that the fume hood is only

one component in the laboratory ventilation system, and that the rate at which air is exhausted through the fume hood can be no greater than the rate at which air enters the laboratory.

In addition to having sufficient (but not excessive) velocity, the air flow within the hood should be uniform. Turbulence may reduce the hood's operating efficiency, and may arise from uneven airflow around equipment placed in the hood, room draughts from open doors or windows (air currents are typically about 0.1 metres/second), or even the presence of the user standing in front of the hood. To achieve maximum efficiency, fume hoods should not be cluttered with unnecessary equipment. In particular, bottles of stored chemicals should be removed to vented storage cabinets. A substantial amount of energy is required to exhaust air through even a small hood, so the use of hoods to store toxic or corrosive chemicals is wasteful, as well as detracting from the performance of its intended function — protecting the laboratory worker.

A hood that is not providing adequate ventilating performance may impart a false sense of security, and thus be more dangerous than no hood at all. Fume hoods may be evaluated by using visible fumes or smoke (these can be generated using cotton swabs dipped in titanium tetrachloride, commercial smoke tubes or aerosol generators). After the operation of each hood has been checked, it should be fitted with an inexpensive manometer so that the user can readily check that the hood is in the same operating condition as when it was evaluated. One side of the manometer should be connected to the duct just above the hood and the other side left open to the laboratory atmosphere. It should be capable of measuring pressure differences in the range of 2.5 - 50 mm of water.

The number of fume hoods and the quality of the ventilation system should be considered a limiting factor determining the type of experiments that are performed and the chemicals which are used in a particular laboratory. In laboratories where workers spend most of their time working with chemicals, there should be at least one hood for each two workers, and the hoods should be large enough to provide each worker with a working space inside a fume hood at least 0.75 metres wide. The optimal arrangement is for each laboratory worker to have a separate hood. Many academic teaching laboratories do not meet these requirements, and it is recommended that such laboratories do not use chemicals whose toxicity and hazards are unknown.

For substances known to be extremely toxic, work may need to be restricted to controlled areas. Although the group which prepared the NRC report feel that regular monitoring of airborne concentrations of toxic substances is not necessary or practical in most laboratories, they advise that such monitoring be carried out when highly toxic substances are used regularly and continuously. Perhaps the most thorough (and also the most time-consuming) way to evaluate the effectiveness of fume hoods and laboratory practice is for laboratory workers to wear personal air sampling devices (these are commercially available).

Fume hoods should not normally be used for disposing of volatile chemical wastes, and should not be a substitute for a conscientious waste disposal system. A well-planned programme of waste collection and disposal may be considered as an important component of safe laboratory practice. Furthermore, chemistry research and teaching organizations are coming under increasing pressure to restrict the amounts and types of waste that are flushed untreated into sewers. In response, some university and industrial laboratories have already established comprehensive waste handling and disposal programmes.

Guidance for establishing a waste disposal programme is provided by the book *Code for the disposal of laboratory waste,* available from the Royal Australian Chemical Institute (191 Royal Parade, Parkville, Victoria 3052, Australia). Another pamphlet, the *Exotic Garbage Booklet,* describes rules for staff members of the University of Western Ontario (Canada) to collect and package wastes for disposal by the university's waste disposal programme (administered by the university's safety officer, Dwight Barratt).

In most waste disposal programmes, emphasis is placed on recovery of solvents and other wastes whenever this is possible. At Carlton University (in Ottawa, Canada), for example, more than 1000 litres of waste hydrocarbon solvents produced by the chemistry department are redistilled and re-used. The 40-or-so litres of chlorinated hydrocarbon waste solvents produced each year are collected and stored separately.

Efficient recycling requires that different types of waste solvents be segregated. What's more, indiscriminate mixing of solvent wastes can be dangerous (some solvents, like chloroform and acetone, should never be mixed). Solvent containers should be disposed of at frequent intervals, since many solvents and solvent mixtures are corrosive and prolonged storage of waste ethers can lead to accumulation of explosive peroxides. For ease of handling, all waste containers should have a capacity of less than 20 litres.

Flushing down a sink is generally satisfactory for the disposal of water-soluble biodegradable materials. Organometallic compounds should first be decomposed to liberate a solution of the metal ions, which if relatively non-toxic, can then be flushed down a drain. Air or water-sensitive organometallic compounds (Grignard reagents, for example) should be destroyed by controlled alcoholysis, hydrolysis or oxidation. Water-soluble volatile liquids, such as methanol and acetone, should be diluted with

Good laboratory design & procedures minimize the threat of fire

Fire poses a special hazard in the chemical laboratory, since flammable solvents and chemicals are frequently handled and often heated. Many common-used organic solvents have sufficient vapour pressure to form combustible vapour - air mixtures, even at well below room temperature. The flash points of some organic liquids (the lowest temperature at which the liquid forms a combustible vapour - air mixture) are well below 0°C, and their vapours can be ignited by a small flame or electrical spark. Even without an obvious ignition source, organic vapours may undergo autoignition at relatively low temperature. Diethyl ether and carbon disulfide are particularly susceptible to autoignition. Ether, with an ignition temperature of 160°C, can be ignited by contact with the surface of a hot plate; carbon disulfide (with an ignition temperature of only 80°C) can be ignited by a steam line or light bulb.

Vapours of all flammmable liquids are heavier than air and are capable of traveling considerable distances along floors, and into stairwells and elevator shafts to lower storeys of the laboratory building. If a continuous path of vapour is produced from a large spill, a flame can propagate from a distant ignition source back to the spill.

One of the most effective ways to prevent the formation of flammable vapour - air mixtures is by diluting and exhausting the fumes within a hood. A fume hood should thus be used, according to the NRC report, whenever appreciable amounts of flammable chemicals are transferred to another container, allowed to stand in open containers, or handled in any way. The installation of thermal detectors within fume hoods has also been recommended. These would give immediate warning of a fire, and could activate the building' s fire alarm system. Such an electrical heat-sensing device could have largely avoided the damage caused by a fire at the Central Research Laboratory at ICI Australian Operations Pty Limited on 15 August 1980. That fire, according to the findings of an investigating team, had evidently been burning for some time within a fume hood (due to failure of an apparatus left on overnight), reducing the underlying bench to ashes before spreading from the hood.

Recommendations made by the investigating team, described in the May 1981 issue of *Chemistry in Australia,* would be applicable to most chemical laboratories. These included the construction of fire-resistant enclosures around fume hood ducts along their entire length through the building. Polyvinyl chloride is commonly used for fume hood ducts because of its exceptional ability to tolerate corrosive fumes but, without a protective enclosure, it cannot contain a fire and prevent its spread to other parts of the building. The ICI group also recommended that each fume hood should be fitted with its own exhaust fan, which should continue to operate in the event of a fire to remove smoke and fumes and help fire-fighters locate the source of the fire.

Because the fire at ICI's Central Research Laboratory had started in an experimental apparatus left running overnight, the investigators focussed their attention towards the development of procedures for conducting experiments after normal working hours. They emphasized that experimenters should obtain authorization for experiments to be left operating overnight, that the conditions under which the equipment be left-on or turned-off should be specified, and that the apparatus should be checked by someone with some knowledge of the experiment.

They also strongly advocated the installation of sprinkler systems. The effectiveness of automatic sprinklers in halting the spread of fires, the investigators concluded, more than offsets the potential hazard of water reacting with chemicals (large quantities of water-sensitive chemicals should be stored separately from other combustible material, in a room *not* equipped with sprinklers). They felt that damage to electronic instruments by water during a fire was not a significant factor, and the possibility of damage to equipment by accidental activation of the sprinkler system was so remote that it could be disregarded.

Unless persistent efforts are made to limit the amount of flammable solvents stored in a laboratory (particularly in laboratories used by a group of people), flammable chemicals and wastes can readily accumulate to the extent that there would be little hope of preventing a fire from becoming an inferno. For this reason, large amounts of flammable waste or unneeded chemicals should not be stored in the laboratory. Small quantities of flammmable liquids should be stored in ventilated steel storage cabinets with an insulating air space between the inner and outer wall.

Storage and dispensing rooms for flammable chemicals should ideally be located in a special building separated from the main laboratory building. This is often not feasible, the NRC report acknowledges, and when flammable liquids must be stored in the same building, the storage room should be separated from other areas by fire-rated construction with at least one wall at the exterior of the building. In no case should the storage room be located on the roof of the building, below ground level, on an upper floor, or in the centre of the building (these locations wouuld restrict the accessibility of fire-fighters or would be potentially dangerous to people in the buildings). Storage rooms should be ventilated by a fan switched on from outside the door. Potential sources of ignition, such as cigarettes and lighted matches, should be prohibited.

water before pouring into a drain to reduce the risk that inflammable vapours might ignite and flash back into the drain.

Inflammable solvents are preferably disposed of by burning in a properly designed incinerator; however, halogenated wastes should not be burned (unless the incinerator is equipped with an afterburner and scrubber to prevent release of hydrogen halides to the atmosphere). Small quantities of halogenated solvents may be evaporated, but large amounts should be stored until arrangements can be made for collection and disposal.

Non-combustible solid wastes, toxic salts or large quantities of inorganic salts can be encased in cement if recycling is not practical. The chemical is first converted to a solid (if necessary) by drying or precipitation, placed in a suitable container, and covered in a sand: cement: water mixture (in the approximate weight ratio of 4:2:1) in a paint tin or plastic bag. The cement container should not be attractive so as to arouse curiousity or encourage retrieval. This procedure is not normally suitable for beryllium and mercury compounds, which are highly toxic and require special precautions for storage and disposal. Special procedures are also required for handling radioactive wastes.

**Prudent Practices for Handling Hazardous Chemicals in Laboratories, by the Committee on Hazardous Substances in the Laboratory of the US National Research Council, 1981. Available from the Assembly of Mathematical & Physical Sciences, National Research Council, 2101 Constitution Avenue NW, Washington, D.C. 20418, USA.*

Break-down of cellulose is key step in making chemicals from biomass

In recent years, there has been an explosion of interest in the use of biomass (plant matter) as a resource for producing fuels and chemicals. Of special interest is the use of agricultural waste (such as maize cobs, rice husk and sugar cane bagasse) that are presently burned, buried or added to animal feed. These wastes could potentially provide a continuous, and very substantial, supply of organic compounds.

Most agricultural wastes are fibrous materials composed largely of cellulose and lignin. Since cellulose is a polymer of glucose, it can be hydrolyzed to sugars, which in turn can be fermented to a wide range of chemical and food products. Unfortunately, cellulose is a complex and relatively unreactive chemical feedstock. Vigorous conditions are usually required for the breakdown of the crystalline structure of cellulose and subsequent hydrolysis of carbohydrate macromolecules, causing a range of products to be produced. Even so, hydrolysis of cellulose is usually a slow process.

Several new technological developments promise to break through this barrier, and allow cellulosic wastes to be quickly and easily converted to useful chemical products. For example, one group at Purdue University (in West Lafayette, Indiana in the USA) has developed a solvent which they report can efficiently dissolve cellulose. The cellulosic waste is first treated with dilute acid or alkali to remove hemicellulose. Cellulose is then dissolved using a solvent consisting of ethylenediamine, water and a small amount of cadmium (Cadoxen). Addition of strong acid almost immediately produces glucose at room temperature, and dilute acid can be used at temperatures of 100 -200°C. An analysis of the economic feasibility of the process, carried out for the US government, shows that fermentable pentose and hexose sugars can be produced from corn stover at a processing cost of about US$100 per metric ton.

Greater ease of cellulose hydrolysis is also achieved with other processes described recently in chemical journals and patent applications. A pretreatment process developed by Verfahrenstechnik GmbH (in the Federal Republic of Germany) allows the cellulose content of biomass to be readily hydrolyzed by acids or enzymes. In the process, biomass is contacted with saturated steam at about 200°C and then treated with an aqueous solution of alkali. A similiar effect is achieved by a physical process developed by Noriisho KK and patented in Japan, which uses freeze-crushing of wood to reduce its particle size and open its crystalline structure to attack by acids or enzymes. A third process, developed by the Pulp & Paper Institute of Canada, converts wood chips into a powder by an explosive release of steam pressure. These wood powders are readily digested by enzymes to give sugar yields comparable to those from acid hydrolysis. The application of enzymes holds great promise for accelerating the hydrolysis of cellulose and increasing the yield of useful products, and a very extensive research effort is underway to enhance the activity of cellulase enzymes.

A team from North Carolina State University

(USA), studying the production of ethanol, furfural and acetic acid by the acid hydrolysis of wood, concluded that this process could now be economically competitive with other methods of producing these compounds. The degree of acid recovery and the demand for the non-ethanol byproducts have a critical bearing on the potential profitability of the process. A similar hydrolysis process has already begun commercial operation in Kenya, utilizing maize cobs as raw material for production of furfural, acetic acid and formic acid.

Hydrolysis is not the only means of upgrading cellulose to useful chemical products. An important alternative is gasification. This produces synthesis gas, a mixture of carbon monoxide and hydrogen, which can be reacted to produce methanol, ammonia, ethanol, acetic acid and a range of other important chemicals. Although coal is now envisaged as the major source of synthesis gas, some new technology developed for coal gasification will likely be applicable to the gasification of biomass. In fact, one paper published last year concluded that hydrogasification of biomass could become economically viable and competitive with coal gasification during the 1990's. The author projected that the technology developed for second-generation entrained-flow coal gasifiers (see feature article in *Chemistry International,* 1980, No.6) and oxygen-blown waste gasifiers would "spill over" into biomass gasification.

Already, this seems to be happening. A new biomass gasifier developed by Standard Solid Fuels Inc (in Seattle, USA), for example, combines a fixed-bed gasifier unit (similar to conventional gasifers) with an entrained-flow unit. The main gasification reactions occur in the high-temperature (900 - 1000°C) zone of the entrained-flow reactor, so that tars and oils are reduced to carbon monoxide and hydrogen. This eliminates the need for impurities-removal equipment, which normally accounts for 25% the cost of a gasifier. The two-stage system can gasify agricultural waste, sludge or coal. Another gasifier design, developed by Garrett Energy Research & Engineering Company utilizes separate hearths for drying, pyrolysis, gasification and combustion of the biomass, with extensive heat exchange between the various stages.

As well as carbon monoxide and hydrogen, other useful compounds can be formed during biomass gasification, and the yields of these compounds can be maximized by altering the conditions in the gasifier. A preliminary study at the Solar Energy Research Institute showed that significant amounts of ethylene can be produced from cellulose or finely divided wood. By pyrolising the biomass very rapidly at temperatures above 700°C, they could produce up to 82 kilograms of synthesis gas and 6 - 9 kilograms of byproduct ethylene per 100 kg of dried wood.

These advances in biomass hydrolysis and gasification are included in a literature survey of new processes for the production of organic raw materials, compiled by IUPAC's Committee on Chemistry and Industry. The survey, which is to be followed periodically by others, will help guide IUPAC's CHEMRAWN Committee in organizing the programme for the 2nd International Conference on Future Sources of Organic Raw Materials (designated CHEMRAWN III, and to be held in Europe in 1983 or 1984). The first survey identifies significant new developments which have occurred since the 1st International Conference on Future Sources of Organic Raw Materials (CHEMRAWN I) was convened in July 1978.

One part of the survey, dealing with *renewable* raw materials for the production of chemicals and plastics, describes plant species that have recently been shown to be promising sources of biomass for chemical manufacture; conversion of biomass into intermediates (sugars and synthesis gas); and conversion of these intermediates to final products. The 31 page report refers to 102 publications in the chemical and patent literature.

A second part of the survey describes recent developments in the production of chemical raw materials from petroleum, natural gas and coal. This 28 page report covers new and improved processes for hydrocarbon cracking, reforming and separation; new coal gasifiers and production of chemicals from synthesis gas; and pyrolysis, solvent extraction and hydrogenation of coal.

A second literature survey has been in preparation, and will likely be available this month. Individuals who would like to obtain a copy of the literature surveys should write to the Secretary of IUPAC's Committee on Chemistry & Industry: Dr. G. Jäger, Bayer AG, D-5090 Leverkusen-Bayerwerk, Federal Republic of Germany.

The chemist in court

Results of chemical analyses are, to an increasing extent, being used as evidence in court. Prosecution of an institution or individual may be based upon chemical analysis of pollutants in an industrial effluent, impurities in a pharmaceutical, excessive preservative in a food product, or identification of a drug residue. Not only has the role of the specialist forensic chemist greatly expanded, but analytical chemists in all fields are being called upon to present evidence in civil and criminal cases. At some time in the future, any chemist could find himself giving evidence in court.

This is an experience for which most chemists are completely untrained and unprepared. For those unfamiliar with the practice of law, a day in court can be a daunting experience. The chemist can find himself being harassed by prosecution or defense attornies, or his testimony misconstrued and used to mislead the jury. Yet, his evidence could be instrumental in committing the defendant to years in prison, or releasing a potentially dangerous individual. The chemist presenting evidence must leave the court with a clear conscience, with the knowledge that his testimony has assisted the court in finding the truth. It is his responsibility that the court not be inadvertently misled by his evidence, or by inferences during cross-examination. He should never allow himself to be pressed or badgered into answering a question in terms which are misleading or untruthful.

The technique of presenting evidence in court is a skill which develops with experience. To guide the chemist around common pitfalls, the Deputy Director-General of the government chemistry department in Malaysia describes here some lessons learned (some, very painfully) during his many court appearances to present expert evidence. Throughout his 20 odd years experience as a forensic chemist, his knowledge and interest in the legal system grew until it paralleled his expertise in analytical chemistry. The author is now also a qualified Barrister-at-Law.

by Harcharan Singh Tara
Deputy Director-General of Chemistry, Malaysia.

The growing role of science in the law

There has been a rapid growth of what are termed "Scientific Offences" — that is, offences which are defined in terms of scientific measurements. These offences are committed when a fixed numerical threshold is exceeded. For example, driving a car at a speed of 44 km/hour might be permitted on a certain road, while driving at 46 km/hour would be committing an offence.

In some countries, a fixed level of blood alcohol is used to define drunken driving, much the same as a speed limit sets the threshold for unlawful speeding. In Singapore, as a typical example, someone driving a car who has a blood alcohol concentration of 119 mg/100 ml is not breaking the law, but if his blood alcohol level is 121 mg/100 ml, he might have to employ a chauffeur.

The Environmental Quality Act (1974) has recently come into force in Malaysia, as have other regulations governing the amount of toxic metals that can be discharged, and the quality of palm oil effluents, rubber waste, industrial effluents and air quality. Fixed limits have been established as allowed concentrations for many components of industrial effluents and exhaust gases. Successful prosecution of organizations which do not comply with these standards depends solely on the results of an analytical chemist.

In other offences, proof of guilt depends upon the detection of trace amounts of drugs like cannabis, heroin or opium, or residues of explosives of firearms discharges. The great French forensic scientist Edmond Locard formulated the "Theory of Mutual Exchange", which stated that at the scene of a crime there is nearly always either something left behind or taken along by the culprit. These are known as "contact traces". It is all but impossible for a criminal to avoid this contact with the environ-

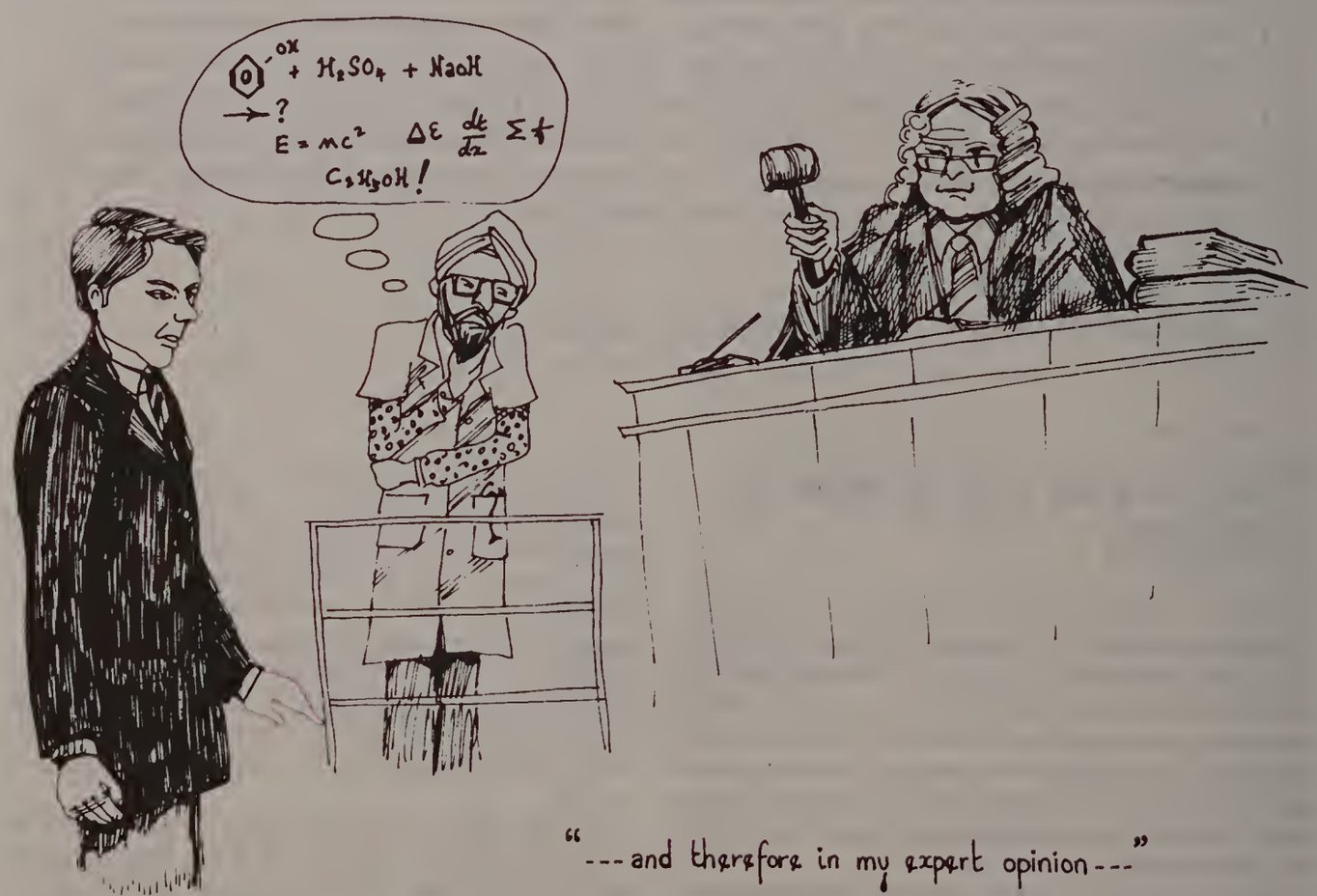
ment at the scene of a crime. Its value as evidence is reduced only by human failuure to find it, examine it, understand and interpret it.

The chemist has two main roles to play in law enforcement. The first is as a member of the team searching for the criminal. In this role, the chemist may provide analytical results to support or refute an initial hypothesis of an investigating police, health or customs officer. This advice is usually required quickly so that it can help determine the direction in which the investigation is to proceed. The results might exonerate or implicate a suspect depending upon, for example, whether his blood group matches a bloodstain at the scene of a crime, or if his particular make of car has paint with the same composition as a paint chip left at the scene of a "hit-and-run" accident.

The second role of the chemist is to provide evidence for a trial. Here, the forensic chemist analyzes physical evidence sent to him for analysis, and prepares a report to be presented in court (as required by Section 399 of the Malaysian Criminal Procedure Code, the Food & Drug Act, Customs Act, the Environmental Quality Act, and other ordinances). His conclusions may either assist prosecution of a suspect, or be cited as evidence to establish the innocence of the accused. It is therefore vital that the chemist present his results as an unbiased third party.

The types of samples which can be chemically analyzed, identified and compared have been greatly expanded by the introduction of new analysis methods. These can reliably detect and measure minute differences in major constituents and trace elements in the sample. The extensive range of techniques which are now routinely available to the chemical analyst include spectrography, x-ray diffraction, polarography, ultra-violet and infrared spectrophotometry, atomic absorption, fluorescence photometry, flame photometry, gas - liquid chromatography, and the combined techniques of gas chromatography-mass spectrometry. The advent of Neutron Activation Analysis has especially been a welcome development in forensic science (see Feature Article in this issue). Many common objects — such as human hair, paint chips, or glass fragments — contain tiny quantities of metals whose concentrations can be accurately measured by this technique. Like other new tools of forensic analysis, neutron activation analysis may be "too sharp" to be used for some tasks. Before we can fully exploit these techniques, we need much more knowledge of the normal distribution of elements in common materials in our normal environment.

Although the individual chemist might use many of these analytical techniques every day, he cannot expect to become expert in all these methods. The only way that the analyst (and perhaps later, a jury) can judge that correct results are obtained is by regularly putting test or standard samples through



It is essential that the judge and jury not be confused by testimony of the technical expert, or by misleading or irrelevant questions posed by the cross-examiner. The expert witness should keep clearly in mind what he hopes to establish by his evidence. At the same time, he must be prepared to provide information necessary for the jury to intelligently evaluate his own conclusions and form their own independent judgement (*cartoon by Mr A. Rahma*).

the system, knowing in advance the composition of the sample. The accuracy and detection limit of a technique must be taken into account before a report is issued as court evidence (it is common practice to report that "not less than xxx milligrams of the substance was present"). It is also very important that the analyst take a representative sample. Many countries have statutory requirements about the taking of samples to be analyzed for court evidence. For chemical analysis results to be admissible evidence in Malaysia, for example, it is required (under sec. 37 (j) of the Dangerous Drugs Ordinance of 1952) that samples be analyzed from at least 10% of the receptacles which have been procured as evidence.

It is not justified for a chemist to provide analytical results as legal evidence by simply using analytical instruments as "black boxes", putting in samples at one end and extracting results at the other. He must at least know the principles of operation behind the instruments he is using, and if neccessary, be able to explain these to the court.

The increased precision with which forensic samples can be analyzed allows the circumstances of a crime to be more clearly established, and will certainly expand the influence of the chemist in and out of court. We can also expect the number and variety of scientific offences to increase further. For one thing, these cases are very easy to decide from the point of view of the court, but impose a great deal of responsibility on the chemist providing expert testimony.

Presenting test results as court evidence

When presenting scientific evidence in court, the chemist is often hampered by his total lack of any formal training in *techniques* of giving evidence. This shortcoming poses a difficult problem to expert witnesses in all scientific specializations. The only way to acquire this skill is by experience, and this can be a painful process in the early stages.

The testimony of an expert differs from the testimony of an ordinary witness. An ordinary witness is not allowed to express an opinion — merely to state facts of which he has personal knowledge. The fundamental principle of the Common Law is that a witness can only testify about what he *saw, heard,* or *felt.* What he heard from another person is generally considered hearsay, and not admissible evidence. Any deduction he may have made because of what he saw, heard or felt is not for him to expound, but for the court. The expert (provided he is qualified and his evidence is admissible) may state both facts within his knowledge and his opinion, based upon the facts available and supported by his experience in his area of specialization or expertise. The precedent for this unique role of the expert witness stems from the case of Folkes versus Chadd (1782). The issue in this trial was whether the construction of an embankment had caused the silting of a harbour. The judge and jury could only *guess* what had caused the silting. Smeaton, an engineer, was allowed to say what he *thought* was the cause. From then on, the witness box was open to the expert witness (we forensic chemists therefore owe our jobs to Smeaton).

Giving expert evidence entails the transfer of (chemical) knowledge from the chemist to lawyers and the jury in the court. What the court usually wants is a firm statement about the linkage between two objects — that is, did a fibre, paint chip, soil, wood or blood sample come from a particular source known to be connected with a particular crime or with an individual accused of the crime.

The legal aspects of presenting scientific evidence to the court are as important as the technical details of the analysis technique. The chemist must always keep clearly in mind what he hopes to establish by his evidence. Whatever miracles the chemist may have performed in the laboratory, whatever sophisticated instruments have been used, whatever deductions have been drawn from analysis of the samples, all must be reduced to *facts and opinions* in court. Lawyers, the jury and judge must understand what you say. "The duty of the expert witness," stated Lord Cooper in Davie versus Edinburgh Magistrates (1953), "is to furnish the judge or jury with the necessary scientific criteria for testing the accuracy of their (the witness') conclusions so as to enable the judge or jury to form their own independent judgement."

Assessment of results by cross-examination

Cross-examination is the means of testing the validity of conclusions expressed by the witness. It is a method of reducing or eliminating the danger that a false conclusion is reached. Its aim is to reveal the truth. Where a witness is speaking the truth or expressing a well-founded opinion, a thorough testing by cross-examination should serve only to enhance the standing of the witness and demonstrate the objectivity and integrity of his evidence.

The method of cross-examination is, however, quite unsuitable for the assessment of scientific evidence. Disagreements may arise because wrong inferences are drawn from the results presented, or from the questions of the cross-examiner. The predicament of the expert witness was well understood by Justice Sir Roger Ormrod, who was a qualified medical doctor before he became a lawyer. He said of cross examination:

> "The questioner is dominant. The form of the question conditions the form, and often the content, of the answers . . . Questions which contain *hidden assumptions* sometimes yield answers which almost contradict the witness' real meaning, unless he is quick enough to detect and expose the assumption."

This is very true, and the chemist in court must be sharp to recognize a "leading question". It has been said that to get an intelligent answer, one must ask an intelligent question, and this is very applicable to the cross-examination of experts.

During cross-examination, counsel may attempt to discredit or cast doubt on your experimental method or conclusions. For example, he might question whether your apparatus was thoroughly clean before beginning the analysis. A simple response that the apparatus had been cleaned might leave an element of doubt in the minds of the jurors. One way of countering this inference is to say, "My Lord, it is normal practice for chemists not to start an analysis using dirty apparatus, just as it is normal practice for the learned counsel not to eat his food out of dirty dishes."

Counsel may intentionally try to mislead the court to believe that statutory requirements (for example, as to amount of sample taken) have not been fulfilled in the analysis of the sample. The expert witness must look out not to fall into the following trap:

Counsel: "Mr. Singh; what is the weight of sample you took for analysis from Packet A, (which contained 125 grams of drug)?
Expert: "One gram, my Lord."
Counsel: "Thank you, Mr Singh, you are released."

The novice may come out of this cross-examination quite pleased with himself, and not even be aware of the inference that he did not analyze sufficient sample. By taking a one gram sample representative of the material in packet A, the analyst *did* comply with the requirement that samples from at least 10% of the receptacle or packages be analyzed. However, the jury may be led to think that the analyst was required to test 10% of the sample in that receptacle — which is not true.

I once saw this sort of questioning coming. Before I was released, I put up my hand (like a school boy asking for the teacher's attention) and asked the judge if I could say something. The judge allowed me, and I started to explain how I took the one gram sample from 125 grams of packet A by a "coning and quartering" method, until I arrived at a representative one gram sample. If I am put in this situation in future, I plan to politely counter, "Surely the learned counsel is not so naive as to suggest that the one gram sample that I analyzed was not *representative* of the entire content of packet A. My Lord, I do not need 10% of 125 grams, or 12.5 grams, for my analysis. With modern instrumentation, a mere 0.1 grams is sufficient — provided of course that it is representative of the whole sample."

Second-rate cross-examination, including abusive tactics, are sometimes used. I was once asked a question about the testing of alcohol, which was quite irrelevant in this opium case. Before I could respond, the counsel shouted "witness, answer the question!" From then on, I refused to look at the counsel directly, and only looked straight at the magistrate. In time, the counsel found that he could only face my ear, his shouting stopped, and he became calm. At other times, derogatory or belittling remarks may be used to deliberately mislead the court. Counsel may build you up by saying, "Mr. Singh, you must be a very busy man, an important man, with lots of important work to do." If you are not careful and say "yes" to all these boasts about your importance, counsel might drop the bombshell, "So Mr. Singh, you could not have had much time to supervise your assistants" (in effect, implying that you did not do the analysis yourself).

A chemist who is hectored by the cross-examiner may appeal to the court for help. The expert witness should never allow himself to be forced into answering a question in terms which cannot constitute a truthful response. The obligation of the witness is to tell the truth, the whole truth (you can ask the court politely "Does the learned counsel want the whole truth or just the bare truth,") and although the questioner is entitled to press his questions, the witness is equally entitled to reply that no meaningful answer to a question is possible. The Court will always afford an opportunity for the witness at the end of his testimony to add his own comment. If he is able to do so in a brief and clear fashion, he may be able to show that the questioner does not understand the subject and that his questions are valueless.

Acknowledgement:
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About the author:

Harcharan Singh Tara joined the Department of Chemistry of the Malaysian government after graduating with a chemistry degree from the University of Malaya in 1959. This Department, of which he is now Deputy Director-General, provides analytical, investigatory and advisory services to the Ministries of Health, Defense, Trade and Industry, Royal Malaysian Police, Royal Malaysian Customs, Public Works Department, Treasury, Bank Negara, Department of the Environment and other Government departments. The Department of Chemistry analyzes the nation's water supplies for the presence of disease organisms, assists law enforcement agencies, provides advice on tariff classifications, checks that government purchases meet specifications, and (especially recently) assists government departments with the responsibility of controlling pollution.

Mr. Singh obtained his M.Sc. degree in analytical chemistry from Imperial College of Science & Technology (London) in 1962. Since then, he has been actively involved in forensic science in Malaysia. After being called on many occasions to present evidence in court, he became interested in court work and began law studies. In 1980, he successfully completed the Barrister-at-Law Examination, and was admitted to Grays INN in 1981.

Neutron activation analysis: a powerful technique becomes available to chemists

For elemental analysis of a wide variety of samples, neutron activation analysis offers high sensitivity and selectivity. Furthermore, it avoids many of the problems encountered with alternative chemical analysis methods (notably, atomic absorption spectrometry and anodic stripping voltammetry), which require that the sample be dissolved in an appropriate solvent. Dissolution of geochemical or biochemical samples frequently requires prolonged boiling with concentrated acids. This opens the possibility for contamination of the acids, incomplete solubilization of the sample, and losses of sample constituents by volatilization. At the very least, dissolution in acid destroys the original sample. On the other hand, neutron activation analysis generally requires little — if any — sample preparation, and does not destroy the sample.

During neutron activation analysis, a sample is bombarded with neutrons in a nuclear reactor, selectively inducing radioactivity in the atoms of its constituent elements. Each "radioactivated" element emits gamma radiation with a characteristic energy, at an intensity which is proportional to the amount of that element in the sample. The different energies of gamma radiation emitted by various elements in the sample are distinguished by the detector of a high resolution gamma spectrometer, and a gamma spectrum (radiation intensity vs energy) is accumulated. This spectrum is a distinctive "fingerprint" from which the exact elemental composition of the sample may be derived. The measurement of the gamma radiation spectrum may be carried out at the reactor site, immediately after the sample is irradiated, or (for analysis of some elements) may be carried out soon afterwards at another site.

The facilities required for neutron activation analysis (including a nuclear reactor) are far less numerous than are atomic absorption spectrophotometers, which are used routinely in most industrial, university and government laboratories. It is therefore not surprising that most analytical chemists use atomic absorption spectroscopy for elemental analysis, while many have never even considered using neutron activation analysis. However, nuclear reactor facilities are more common than is generally assumed. There are, at present, about 70 research reactors for neutron activation analysis in North America alone, and more than 100 throughout the rest of the world. Most are small, low-cost reactors designed specifically to provide low power levels (a few kilowatts to one megawatt) and modest neutron fluxes (10^{11} - 10^{13} neutrons/cm^2 per second) suitable for neutron activation analysis. Facilities at many research reactors are made available to scientific staff of institutions which do not have a reactor. These reactors and gamma radiation spectrometers represent a resource which has hardly been tapped by chemical researchers.

by Sidney A. Katz
Rutgers — The State University of New Jersey (USA).

Many chemical, biological and medical scientists are currently concerned with the role of trace elements in biological systems and the fate of these elements in the environment. Some employ neutron activation analysis to measure levels of essential and toxic trace elements in a wide variety of sample materials. The technique has found extensive application in academic disciplines ranging from archaeology to zoology. In industry, neutron activation analysis is used routinely to determine trace contaminant levels in high purity materials.

Neutron activation analysis has successfully been able to resolve, or at least clarify, significant and long-standing controversies in history, art, law and — of course — science. For example, some historians have questioned the belief that Napoleon I died as a result of stomach cancer. Some suggest that he might have been poisoned with arsenic while held prisoner at Longwood on Saint Helena. Historians were delighted when an authenticated sample of Napoleon's hair, a tissue known to accumulate heavy metal poisons ingested into the body, was made available for neutron activation analysis. The analysis showed that Napoleon's hair did indeed contain significant amounts of arsenic. It was not, however, possible to ascertain if the arsenic was deliberately administered as a poison or if it resulted from the voluntary ingestion of a medication containing an arsenic compound.

Insight into ancient history was also gleaned by the determination of copper, silver and gold content of ancient coins. One historian wanted to know if ancient civilizations (specifically the ancient Romans) debased their coinage during periods of economic hardship. The elemental content of Roman coins, measured by neutron activation analysis, *did* in fact correlate with military successes and failures, changes in government leadership and other historical events. The content of precious metals in the coins was found to be a good general indication of prevailing economic, military and political conditions.

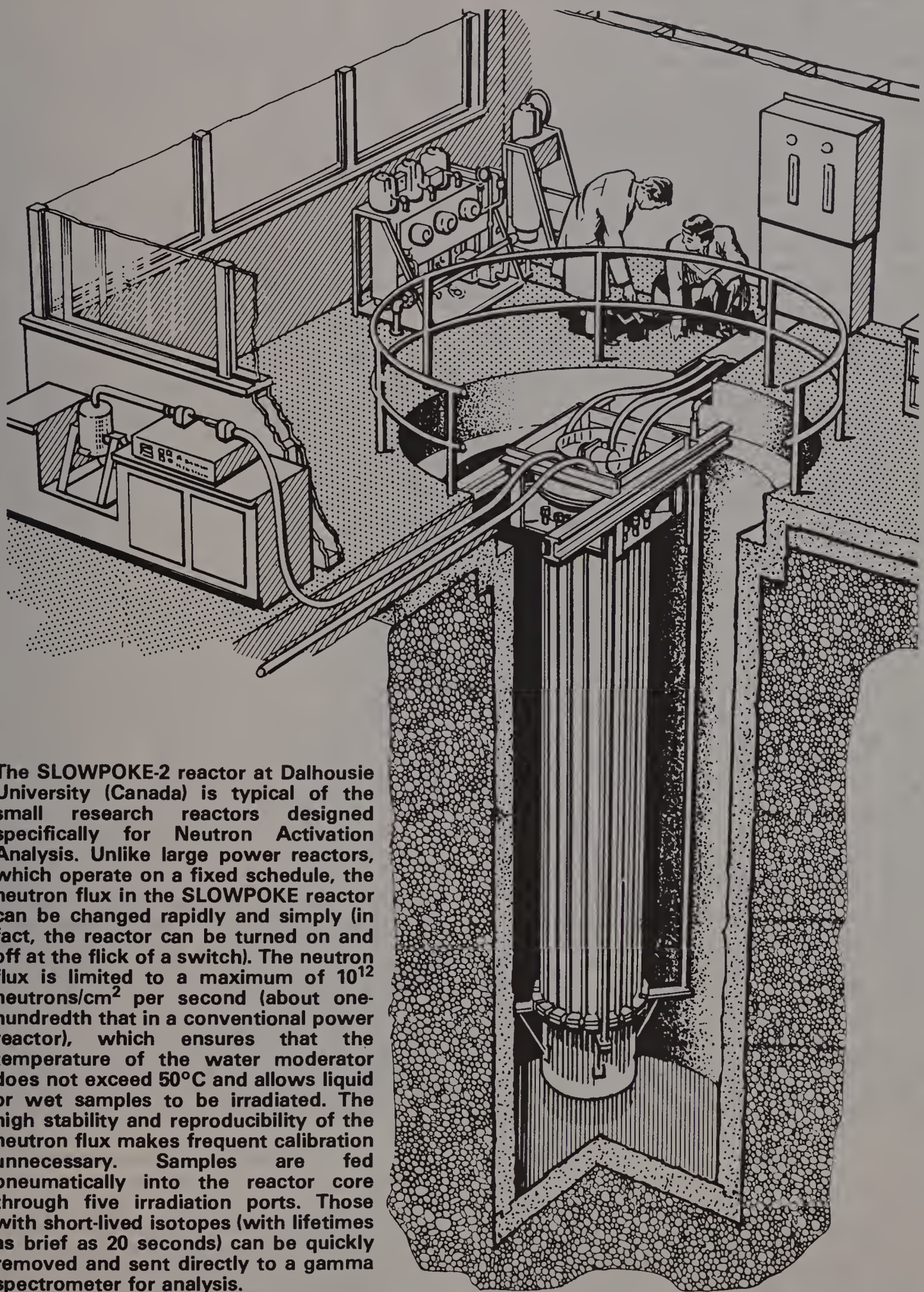
Napoleon's hair and the Roman coins could have been analyzed by conventional chemical techniques. These, however, would have required the destruction of the sample. Neutron activation analysis is a nondestructive technique. The elemental composition can be determined, without damage to the sample, for items of great historical significance or of great artistic value. Such items can be radioactivated by neutron bombardment in a nuclear reactor, their gamma radiation spectrum measured, and then the samples returned to their owners essentially unchanged. Their return, however, must be delayed until the induced radioactivity has decayed to a low level.

Art forgeries can often be identified by neutron activation analysis. It is a relatively simple procedure to remove a minute speck of paint from a "great work of art", subject the speck to neutron activation analysis, and compare its elemental composition to the pigments known to have been used during the period when the work was alleged to have been done. Neutron activation analysis of green pigments can, for example, identify forgeries or confirm the authenticity of paintings that are more than 200 years old. Centuries ago, artists used malachite, a mineral composed of copper carbonate, as a green pigment. Chrome green (which contains chromium) and Paris green (an arsenic compound) were used as pigments in the 19th century. Present-day paints used phthalocyanine green as a pigment, and it contains both copper and chlorine. Obviously, if the green pigment from the work of an "old master" contains copper *and* chlorine, the work was painted long after its reputed artist had died. Analysis of other pigments can also pinpoint forgeries. One work that had allegedly been painted by Vermeer, a 17th century Dutch artist, was found to contain cobalt blue, a pigment not discovered until the 19th century.

The determination of the elemental composition of pigments by neutron activation analysis has also been applied to match paint on the automobile of a suspected hit-and-run driver with small particles of paint embedded in the victim's body. For such applications, attempts are made to match the samples both qualitatively and quantitatively. The match between the paint from the victim's body and from the suspect's automobile must be "beyond a reasonable doubt"; that is, the match must be at least as good as that used in fingerprint identification. As many elements as possible are analyzed to produce elemental fingerprints of the two samples.

Elemental "fingerprints" were the main evidence which led to the successful prosecution of a man accused of cutting and stealing copper wire from a telephone line near Sumter, South Carolina (USA). Shortly after the theft, police recovered 22 pieces of copper wire (of the same size and approximately the same quantity as had been stolen) from the salvage yard in Sumter. The yard manager was able to identify the man from whom he had bought the wire. This individual stated to police that he had purchased the wire from a friend in another state. Samples of the wire recovered from the salvage yard and end pieces of wire left on the poles were radioactivated for 8 hours. The gamma radiation emission spectrum was recorded three weeks later, by which time nearly all the short-lived copper-64 and copper-66 radioisotopes would have decayed, eliminating interference with measurement of radiation from trace elements. Under these conditions, it was possible to measure the concentrations of tin, antimony, silver and cobalt that were present in the copper wire. Concentrations of these elemental impurities in all 22 lengths of wire recovered from the salvage yard matched closely with the composition of the cut wire remaining on the telephone poles. The jury considered this and other evidence, and found the defendant guilty.

Neutron activation analysis is not limited to such down-to-Earth samples. This technique, as well as others, was used to establish the elemental composition of samples brought from the moon's surface by the Apollo space missions. It appears that, on the basis of results from some 200 laboratories, the elemental composition of the "moon rocks" is generally similar to that of basaltic achondrites. The content of rare earth elements, however, appears to be slightly enriched and the more volatile elements



The SLOWPOKE-2 reactor at Dalhousie University (Canada) is typical of the small research reactors designed specifically for Neutron Activation Analysis. Unlike large power reactors, which operate on a fixed schedule, the neutron flux in the SLOWPOKE reactor can be changed rapidly and simply (in fact, the reactor can be turned on and off at the flick of a switch). The neutron flux is limited to a maximum of 10^{12} neutrons/cm^2 per second (about one-hundredth that in a conventional power reactor), which ensures that the temperature of the water moderator does not exceed 50°C and allows liquid or wet samples to be irradiated. The high stability and reproducibility of the neutron flux makes frequent calibration unnecessary. Samples are fed pneumatically into the reactor core through five irradiation ports. Those with short-lived isotopes (with lifetimes as brief as 20 seconds) can be quickly removed and sent directly to a gamma spectrometer for analysis.

By its second year of operation, the SLOWPOKE-2 facility was analyzing 4000 samples from 20 staff members, 16 student researchers, 3 visiting scientists (including the author) and four licensed operators. (*Illustration from the 1977—78 Annual Report of Dalhousie University SLOWPOKE-2 facility.*)

Sensitivities for analysis of elements by neutron activation analysis

Element	Nuclide measured	Gamma emission, keV	Sensitivity counts/ug*
Aluminum	^{28}Al	1779	4.0×10^{3}
Antimony	^{122}Sb	564	6.0×10^{2}
Argon	^{41}Ar	1294	1.4×10^{3}
Arsenic	^{76}As	559	1.4×10^{3}
Barium	^{139}Ba	166	1.2×10^{3}
Bromine	^{80}Br	617	9.6×10^{3}
Cadmium	^{111m}Cd	245	6.2×10^{2}
Calcium	^{49}Ca	3083	2.0×10^{1}
Carbon	^{11}C	511	4.0×10^{-4}
Cerium	^{143}Ce	293	1.9×10^{1}
Cesium	^{134m}Cs	127	5.8×10^{3}
Chlorine	^{38}Cl	1642	3.7×10^{2}
Chromium	^{51}Cr	320	3.3×10^{0}
Cobalt	^{60m}Co	59	2.5×10^{4}
Copper	^{66}Cu	1039	1.3×10^{3}
Dysprosium	^{165m}Dy	108	2.9×10^{5}
Erbium	^{171}Er	308	1.4×10^{3}
Europium	^{152m}Eu	122	3.0×10^{5}
Fluorine	^{20}F	1633	5.4×10^{1}
Gadolinium	^{161}Gd	360	6.6×10^{3}
Gallium	^{72}Ga	834	1.2×10^{3}
Germanium	^{75m}Ge	140	4.5×10^{2}
Gold	^{198}Au	412	1.7×10^{4}
Hafnium	^{179m}Hf	214	5.2×10^{4}
Holmium	^{166}Ho	81	4.9×10^{3}
Indium	^{116m}In	417	6.7×10^{5}
Iodine	^{128}I	443	2.0×10^{4}
Iridium	^{194}Ir	329	7.6×10^{3}
Iron	^{56}Mn	847	7.0×10^{-1}
Krypton	^{85m}Kr	151	2.7×10^{2}
Lanthanum	^{140}La	487	8.2×10^{2}
Lead	^{204m}Pb	375	2.6×10^{-1}
Lithium	^{18}F	511	1.9×10^{2}
Lutetium	^{176m}Lu	88	3.0×10^{4}
Magnesium	^{27}Mg	844	2.0×10^{2}
Manganese	^{56}Mn	847	4.8×10^{4}
Mercury	^{197}Hg	69	5.0×10^{2}
Molybdenum	^{101}Tc	307	9.2×10^{2}
Neodymium	^{151}Nd	117	3.0×10^{3}
Neon	^{23}Ne	440	9.5×10^{-1}
Nickel	^{65}Ni	1115	5.0×10^{0}
Niobium	^{94m}Nb	871	1.2×10^{2}
Nitrogen	^{13}N	511	2.6×10^{-1}
Osmium	^{193}Os	63	1.3×10^{2}
Oxygen	^{19}O	197	1.0×10^{-2}
Palladium	^{109m}Pd	189	6.4×10^{3}
Phosphorus	^{28}Al	1779	5.0×10^{0}
Platinum	^{199}Pt	543	4.9×10^{2}
Potassium	^{42}K	1525	1.1×10^{1}
Praseodymium	^{142}Pr	1576	3.5×10^{1}
Rhenium	^{188m}Re	62	2.8×10^{4}
Rhodium	^{104m}Rh	51	1.1×10^{5}
Rubidium	^{86m}Rb	556	3.6×10^{2}
Ruthenium	^{105}Ru	724	1.3×10^{2}
Samarium	^{155}Sm	104	1.4×10^{5}
Scandium	^{46m}Sc	143	9.7×10^{4}
Selenium	^{77m}Se	162	6.4×10^{3}
Silicon	^{28}Al	1779	1.5×10^{1}
Silver	^{110}Ag	658	4.6×10^{3}
Sodium	^{24}Na	1369	4.3×10^{2}
Strontium	^{87m}Sr	388	4.3×10^{2}
Sulfur	^{37}S	3102	4.1×10^{-1}
Tantalum	^{182m}Ta	172	5.0×10^{2}
Tellurium	^{131}Te	150	2.7×10^{3}
Terbium	^{160}Tb	299	6.5×10^{1}
Thallium	^{202}Tl	440	7.3×10^{-3}
Thorium	^{233}Th	86	5.5×10^{3}
Thulium	^{170}Tm	84	2.5×10^{1}
Tin	^{125m}Sn	332	1.4×10^{3}
Titanium	^{51}Ti	320	7.9×10^{2}
Tungsten	^{187}W	134	7.7×10^{2}
Uranium	^{239}U	74	2.1×10^{5}
Vanadium	^{52}V	1434	7.7×10^{4}
Xenon	^{137}Xe	455	7.8×10^{2}
Ytterbium	^{177}Yb	150	8.6×10^{2}
Yttrium	^{89m}Y	909	3.6×10^{1}
Zinc	^{69m}Zn	439	1.5×10^{1}
Zirconium	^{97}Zr	743	4.0×10^{0}

**The sensitivities cited above (determined at the Trace Analysis Research Centre of Dalhousie University, Halifax, Nova Scotia, Canada) were measured with a sample irradiation time of either 1 or 10 minutes, an equal period of gamma counting, and an intermediate delay of 10 seconds or 1 minute respectively. Higher sensitivities can be obtained by optimizing irradiation and delay time for each element, but this would make the analysis more complicated and time consuming.*

appear to be slightly depleted. These modest differences may reflect the geochemical history of the moon.

Elemental "fingerprinting" by neutron activation analysis has found significant application in archaeological sciences. Comparison of the elemental composition of clay deposits and finished ceramic materials has led to the identification of ancient pottery manufacturing sites, and has allowed researchers to deduce ancient routes of commerce. Similar information can be obtained about the origin of ancient glass objects or their fragments. However, very little information can generally be obtained from gold and silver objects. Gold and silver are frequently resmelted, and the original trace element composition is lost when these metals are refined with others of different origins.

It is perhaps ironic that neutron activation analysis has proven to be one of the most versatile techniques for deriving information about the activities of men and societies living hundreds or thousands of years ago, since its invention and use would not have been possible without the knowledge of nuclear reactions gained since the development of nuclear reactors.

The nuclei of a given element undergo several different nuclear reactions when a sample is inserted into the core of a nuclear reactor. Most nuclei of that element undergo no reaction during the short time

that the sample is bombarded with neutrons. Usually, some nuclei of each element will be converted to radioactive products, and the sample is then said to have been "radioactivated".

Let us consider, for example the possible consequences when a neutron strikes a nucleus of aluminum-27, which is the only isotope that is normally present in aluminum (about 20 other elements are similarly monoisotopic in nature). Neutron impact initially causes a highly-excited ^{28}Al nucleus to be produced. This excited nuclear state can release excess energy as gamma radiation (leaving ^{28}Al as the initial product), eject a proton (forming ^{27}Mg), or emit an alpha particle (yielding ^{24}Na as reaction product). At the low neutron impact energies prevalent in most nuclear reactors, emission of gamma radiation predominates. These reactions are most frequently used for neutron activation analysis.

Radioactive isotopes begin to form as soon as the sample is inserted into the nuclear reactor. These nuclei accumulate in the sample but, as their concentration increases, decomposition (radioactive decay) begins to occur at a significant rate. Once ^{28}Al nuclei are formed by neutron bombardment of an aluminum sample, for example, they soon decay to stable ^{28}Si nuclei. The decomposition is accompanied by release of a photon of gamma radiation with 1.779 MeV energy and by ejection of a high energy electron (beta particle), from the nucleus. The half-life of this radioactive decay is 2.3 minutes. Thus, once the sample has been in the reactor for more than a few minutes, the rate of decay of ^{28}Al is almost as great as its rate of production. Only a limited amount of additional ^{28}Al would then be formed by further neutron bombardment of the sample in the reactor.

Once the sample is removed from the reactor, radioisotopes continue to decompose and emit radiation. When a gamma photon emitted by the sample strikes a Ge(Li) detector, it ejects valence electrons in the semiconductor and gives rise to electrically-conducting electron-hole pairs. The resulting electrical current through the semiconductor detector is proportional to the energy of the gamma photon. The signal is sorted by a multichannel analyzer, and stored as one count in a channel corresponding to the energy of the gamma photon (1.779 MeV for aluminum-28). When the detector is struck by a second gamma photon emitted by the same radioactivated element, a second count will be registered in the same channel. The longer the period that the spectrum is accumulated, the greater will be the signal corresponding to each element. In this way, the sensitivity of the gamma spectrometer can be increased—but only up to a point: the intensity of radiation from each radioactivated element diminishes exponentially with time.

Most elements present in the sample undergo radioactivation, and could be detected by its emission of gamma photons. If sodium is present, for example, neutron bombardment converts the normal ^{23}Na nuclei to the unstable ^{24}Na isotope. This decomposes (with a half-life of 15 hours) to unstable ^{24}Mg, emitting two gamma photons of 2.754 MeV and 1.369 MeV energy and a beta particle. The gamma photons induce an electrical signal in the detector, and produce counts in the channels corresponding to photon energies of 2.754 and 1.369 MeV. Although the 2.754 MeV photons and the 1.369 MeV photons are emitted in identical numbers, the number of counts accumulated in channel 2754 will be less than the counts stored in channel 1369 because the Ge(Li)

Standard Reference Materials for neutron activation analysis

GEOCHEMICAL STANDARDS

Basalts

BR from Centre de Recherches Petrographiques et Geochimiques, France

JB-1 from the Geological Survey of Japan

BCR-1 from the U.S. Geological Survey

BM from Zentrales Geologisches Institut, DDR

Granites

GA, GH and GR from Centre de Recherches Petrographiques et Geochimiques, France

G from the National Institute of Metallurgy, South Africa

G-1 and G-2 from the U.S. Geological Survey

GM from Zentrales Geologisches Institut, DDR

BIOCHEMICAL STANDARDS

Animal tissue

1577 (bovine liver), 1566 (oyster tissue) from the U.S. National Bureau of Standards

A-12 (animal bone), H-4 (muscle) and A-2 (dried animal blood) from the International Atomic Energy Agency, Vienna

Plant tissue

1567 (Wheat flour), 1568 (rice flour) 1570 (spinach), 1571 (orchard leaves), 1573 (tomato leaves) and 1575 (pine needles) from the U.S. National Bureau of Standards

V-5 (wheat flour), V-8 (rye flour) and V-9 (cotton cellulose) from the International Atomic Energy Agency, Vienna

ENVIRONMENTAL STANDARDS

Water

1641, 1642 and 1643 from the U.S. National Bureau of Standards

W-3/1 and W-1/2 from the International Atomic Energy Agency, Vienna

Air

1648 (urban particulate matter) and 1633 (coal fly ash) from the U.S. National Bureau of Standards

Air-1/1 and Air-3/1 (simulated deposition on air filter) International Atomic Energy Agency, Vienna

Sediment

1645 from the U.S. National Bureau of Standards

SL-1 from the International Atomic Energy Agency, Vienna

Some international centres for neutron activation analysis

Argentina

Comision Nacional de Energia, Av. del Libertador 8250, Buenos Aires

Austria

Osterreichische Studiengesellschaft fur Atomenergie, Forschungszentrum, A 2444 Seibersdorf

Bangladesh

Atomic Energy Centre, Post Office Box 164, Dacca

Belgium

Rijksuniversiteit Gent, Institute for Nuclear Sciences, Proeftuinstraat 86, B-9000 Gent

Brazil

Instituto de Energia Atomica, C P 11049, San Paulo, S. P.

Canada

University of Toronto, Toronto, Ontario M5S 1A4

Ecole Polytechnique de Montrael, Montreal, Quebec

Dalhousie University, Halifax, Nova Scotia B3H 4J1

China, Republic of

Institute of Nuclear Science, National Tsing Hwa University, Hsin Chu, Taiwan

Czechoslovakia

Nuclear Research Institute, Rez (near Prague)

Denmark

Danish Atomic Energy Commission, Research Establishment RISO, Ruskilde

Finland

Reactor Laboratory, Technical Research Centre, Espoo

Germany, Democratic Republic of

Zentralinstitut fur Kernforschung, Rossendorf bei Dresden

Germany, Federal Republic of

Hahn-Meitner Institut fur Kernforschung, Berlin GmbH, Glienicker Strasse 100, 1000 Berlin 39

Nuclear Research Centre, D-5170 Julich

Hungary

Central Research Institute, 114 Post Office Box 49, H-1525 Budapest

India

Bhubha Atomic Research Centre, Trombay, Bombay 400-085

Indonesia

Pusat Reaktor Atom Bandung, Djalan Kapitan Pattimura 71, Bandung

Iran

Atomic Energy Organization of Iran, Post Office Box 3327, Teheran*

Italy

Comitato Nazionale per l'Energia Nucleare, Centro Studi Nucleari—Cassaccia, 00100 Rome

Commission of the European Communities, Joint Research Centre, Ispra Establishment, 121020 Ispra Va.

Japan

Research Reactor Institute, Koyoto University, Kumatori-cho, Sennan-gun, Osaka 590-04

Mexico

Centro Nuclear de Mexico, INEM, Mexico

Netherlands

Interuniversity Reactor Institute, Mekelweg 15, Delft

Reaktor Centrum Nederland, Petten

Norway

Institute for Atomenergi, 2007 Kjeller

South Africa

Atomic Energy Board, Private Bag X256, Pretoria 0001

Southern Universities Nuclear Institute, Post Office Box 17, Faure 7131

Spain

Junta de Energia Nuclear, Madrid

Sweden

A B Atomenergi, Studsvik 611 01, Nykoping

Thailand

Office of the Atomic Energy for Peace, Srirubsook Road, Bangkhen, Bangkok 9

United Kingdom

University of London Reactor Centre, Silwood Park, Sunninghill, Ascot, Berks SL5 7PY

Atomic Energy Research Establishment, Harwell, Oxon

Scottish Universities Research and Reactor Centre, East Kilbride, Glasgow G75 0QU

United States

Cornell University, Ithica, New York 14850

Georgia Institute of Technology, Atlanta, Georgia

University of Missouri, Columbia, Missouri 65201

Texas A & M University, College Station, Texas 77843

Washington State University, Pullman, Washington 99164

Western New York Nuclear Research Center, Power Drive, Buffalo, New York 14214

National Bureau of Standards, Washington, D.C. 20234

Argonne National Laboratories, 9700 South Cass Avenue, Argonne, Illinois 60439

Brookhaven National Laboratories, Upton, New York

Oak Ridge National Laboratories, Oak Ridge, Tennessee

Veterans Administration Hospital, Omaha, Nebraska 66105

Yugoslavia

Jozef Stefan Institute, University of Ljubljana, Jamova 39, 61000 Ljubljana

**The current status of the Iranian facility was unknown at the time of writing.*

detector is less efficient in responding to photons of higher energy. The gamma ray spectrum of aluminum foil with a sodium impurity would thus have "photopeaks" in channels 1369, 1779 and 2754. To relate the number of counts in each of these channels to the actual concentrations of aluminum and sodium in the sample, the spectrometer must be calibrated with known amounts of sodium and aluminum.

The calibration of the gamma spectrometer is two dimensional: Firstly, each channel number in the gamma spectrum must be related to its respective gamma photon energy (and hence, from which element it originated). This is established by recording the gamma spectra of known radioisotopes, and adjusting the gain of the detector amplifier (usually, so that 1 keV corresponds to one channel number). Secondly, the number of counts in each channel must be related to the weight of that element present in the sample. This calibration is accomplished by radioactivating known weights of pure elemental standards or standard reference materials, and calculating the number of counts in the appropriate channel per unit weight of each element.

Laboratories engaged in neutron activation analysis use pure elemental standards, as well as standard reference materials (such as hair, metal alloys or paint). Standard reference materials have a known composition of elements in a matrix very similar to that of the sample. A wide range of standard reference materials are now available, and addresses from which some may be obtained are provided with this article.

OFF THE PRESS

Recent IUPAC publications

Hydrogen and deuterium (Solubility data)

About 500 literature references dealing with the solubilities of hydrogen and deuterium have been compiled and evaluated in the preparation of this volume. It considers the solubility of hydrogen at pressures up to 200 kilopascals (two atmospheres) in water; seawater and aqueous salt solutions; organic solvents; aliphatic and aromatic hydrocarbons; organic compounds containing oxygen, halogen, sulfur or nitrogen; and miscellaneous biological fluids. Solubility of deuterium at pressures up to 200 kPa are considered in a separate chapter. At pressures above 200 kilopascals, the solubilities of hydrogen and deuterium are provided for the following solvents: water, aqueous solutions, hydrocarbons, organic compounds containing oxygen and nitrogen, miscellaneous organic fluids, and inorganic compounds.

Solubility data for hydrogen, hydrogen deuteride and deuterium gas are presented as they were reported in the scientific literature. When two or more laboratories reported consistent data over the same range of temperature and pressure, the compilers have evaluated the data and recommended preferred values. A general evaluation is provided when detailed comments on individual measurements are not possible. Users have the option of using the reported solubility measurements (directly, or in their own smoothing equations) or, in some instances, using the smoothed values prepared by the compilers and evaluators.

Edited by Dr. C. L. Young, this combined 5th and 6th volume of the IUPAC Solubility Data Series contains 664 pages. The hardcover book is scheduled for publication in August, and will cost £100 or US$200.

Oxygen and Ozone (Solubility data)

This 7th volume of IUPAC's Solubility Data Series contains an extensive compilation and evaluation of data dealing with the solubility of oxygen and ozone in water, aqueous salt solutions, hydrocarbons and organic solvents (including compounds containing oxygen, halogens, sulfur or nitrogen), and biological fluids, at pressures up to 200 kPa (two atmospheres). A separate chapter deals with solubilities of oxygen at higher pressures. In preparing this volume, the scientific literature has been systematically searched starting with the work of W. Henry in 1803 and extending through the end of 1980. About 800 literature references are cited. Not included within the scope of this volume are gas solubilities in molten salts, alloys, glasses and slags.

The 532 page hardcover volume has been edited by Prof. R. Battino. It is expected to be available in October, at a price of £50 or US$100.

Compendium de la Nomenclature en Chimie Analytique

This book is a translation of the **Compendium of Analytical Chemistry,** published in 1978 and available from Pergamon Press. The accuracy of the translation has been checked by several eminent scientists with specialised knowledge of analytical chemistry terminology. Its translation into French and its production have been coordinated by Prof. J. C. Merlin (President of the Analytical Chemistry Division of the Societe Chimique de France) and Jacques Devynck (Executive Secretary of the same Division).

Those who wish to purchase the 254 page hardcover volume should write to the Societe Chimique de France, 250 rue Saint-Jacques, 75005 Paris, France. The price is 180 Swiss Francs for members of Societe Chimique de France, and 300 Francs for non-members.

Coal-derived liquid fuels provide H_2 for fuel cell power, vehicle propulsion

The attraction of hydrogen as a fuel has long been apparent, and an enormous research effort is underway to develop the technological base for a "hydrogen economy". From an environmental standpoint, hydrogen is an ideal fuel. When hydrogen is burned in a conventional engine, water vapour is the only combustion product. However, to realize the major advantage of hydrogen fuel, it would not be burned in an engine, but would be oxidized in a fuel cell. In this way, its combustion energy is converted directly to electricity, avoiding the inherent inefficiency of converting heat energy to mechanical power. Fuel cells are no longer exotic devices useful only for powering spacecraft: technology developed in the last decade has greatly increased their efficiency, extended their operating lifetime and decreased their cost. Present-day fuel cells offer a realistic option for reliable, silent vibration-free power generation, whenever hydrogen is available.

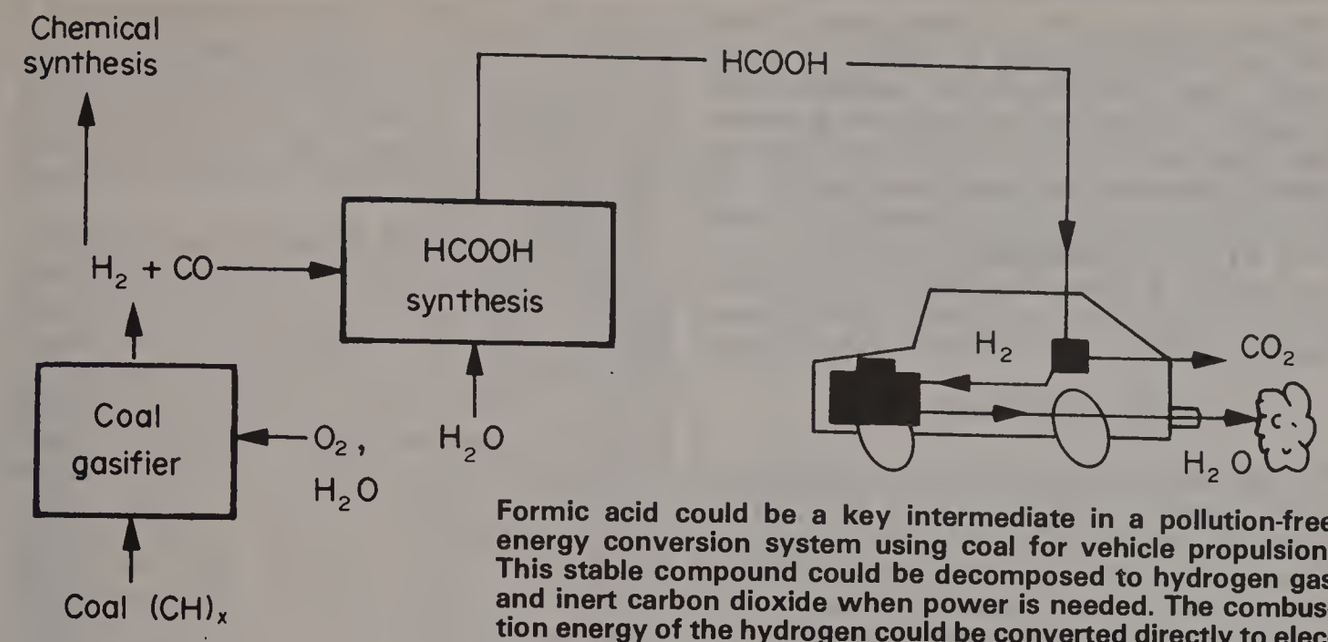
The problem with hydrogen is that it is a gas. Even when compressed to fairly high pressure, gaseous hydrogen contains relatively little energy per unit volume. Somewhat less storage space is required for metal hydrides, which reversibly bind hydrogen gas. But here too, serious difficulties would be encountered in refueling. Present transportation systems are "geared" to liquid fuels. To change to a gaseous fuel would pose enormous cost and technological problems — not only because of the magnitude of the change, but also because gases are much more difficult to handle than liquids.

The ideal energy storage medium would be a liquid compound which could be readily decomposed to provide hydrogen (and inert carbon dioxide) when power is needed. The compound must be stable for long periods, and not decompose spontaneously. It must have a high content of hydrogen. In the presence of a catalyst, the compound must rapidly liberate its hydrogen and divest nearly all its energy to the hydrogen product. Technology must exist to make the compound in enormous quantities from coal, biomass or other energy resources in abundant supply. Finally, it must be relatively inexpensive.

Two compounds meet these requirements: methanol and formic acid. Both are candidates to replace petroleum-derived hydrocarbons in the 21st century, and provide an alternative to synthetic hydrocarbon motor fuels made from coal.

by A. M. Egorov, M. V. Recharshky & I. V. Berezin
Laboratory of Thermochemistry
Lomonsov State University (USSR).

Application of methanol to power engineering is not a novel idea. Forty years ago, many vehicles in Europe were powered by methanol fuel. Modern atuomobile engines, with only minor modification, function very well with pure methanol as fuel. Sometimes, methanol is used in racing cars. One experimental methanol-powered engine, developed recently by Nissan Motor Company, is reported to achieve very high efficiency and low pollution emissions. The methanol is decomposed to hydrogen and carbon monoxide in a catalytic reformer heated to 300°C by the hot engine exhaust. The H_2/CO product gases are mixed with air and distributed to the engine combustion cylinders, where complete combustion is achieved with very lean fuel gas/air mixtures.



Formic acid could be a key intermediate in a pollution-free energy conversion system using coal for vehicle propulsion. This stable compound could be decomposed to hydrogen gas and inert carbon dioxide when power is needed. The combustion energy of the hydrogen could be converted directly to electricity in a fuel cell, or used to power a conventional engine. Potentially, this system could be a more efficient method to provide transport energy than the synthesis of hydrocarbon fuels from coal.

Methanol is now used principally by the chemical industry as a feedstock for the production of formaldehyde and other organic compounds. It is a major industrial chemical, with overall world production amounting to over 15 million tons per year. Methanol is now made from natural gas and coal, although virtually any carbon source could be used — including peat, heavy oils or agricultural refuse. The carbon source is gasified by reaction with oxygen and steam, yielding a mixture of hydrogen and carbon monoxide — termed "synthesis gas". To make methanol (and several other important chemicals), it is necessary that the H_2/CO ratio of these reactants be increased. This is achieved by a "shift reaction", in which carbon monoxide in the product gas is reacted with steam. Technology for the production and processing of synthesis gas is well established and is used, for example, by the massive Sasol project in South Africa to produce hydrocarbon motor fuels from coal. The Sasol project uses conventional Lurgi gasifiers, but second generation (Entrained-flow) gasifiers have been developed in recent years that are better suited and more efficient for the production of synthesis gas (see feature article in *Chemistry International,* 1981, No. 6). These new gasifiers produce H_2/CO mixtures containing about 70 - 75% the energy content of the coal feed. This means, of course, that 25 - 30% of the energy of the coal feed is lost, but this is an acceptable price for the enormous upgrading achieved in producing hydrogen from coal or refuse-energy sources that are complex, dirty, highly variable in composition, and physically dificult to handle. Gasification presents an environmentally-acceptable option for the utilization of high-sulfur or low-grade coals. The reducing atmosphere in a gasifier converts the sulfur content to hydrogen sulfide, which is much easier to remove from the gas stream than is sulfur dioxide (produced when coal is burned). All types of coal, of all particle sizes, can be gasified in new Entrained-flow gasifiers.

Formic acid is another compound, made from synthesis gas, which holds promise as a hydrogen storage intermediate. Like methanol, formic acid is a liquid that is stable for years in the absence of catalysts. Both formic acid and methanol are miscible with water in all proportions.

Formic acid is made from carbon monoxide. The CO is separated from synthesis gas, and remaining hydrogen used for the production of other chemicals (notably, ammonia and methanol). If we expect to produce enormous quantities of formic acid, we would choose a gasifer with the highest yield of carbon monoxide. For this, the Shell-Koppers gasifer might be ideal. Its product gas has the highest content of carbon monoxide (about 64%), the least carbon dioxide, and a thermal efficiency among the highest (in some cases, above 75%) of the second-generation coal gasifiers.

The conventional process for formic acid manufacture involves reaction of carbon monoxide with aqueous sodium hydroxide, and liberation of formic acid by subsequent reaction with sulfuric acid. Sodium sulfate is produced as a byproduct. Two new processes have recently been developed (by the Leonard Process Company and by Scientific Design) which require carbon monoxide and water as the only reagents, and produce no byproducts. The Leonard Process involves reaction of carbon monoxide with a methanol intermediate, which is subsequently recovered and recycled. The initial methyl formate product is then reacted with steam, liberating the methanol and formic acid. The overall reaction is:

$$CO + H_2O \longrightarrow HCOOH.$$

Conversion of carbon monoxide to formic acid is nearly complete. However, although the reaction is slightly exothermic, the process requires a substantial amount of low-grade steam heating.

When in contact with a suitable catalyst, formic acid decomposes, liberating hydrogen and carbon dioxide. This reaction does not normally occur, although the Free Energy of formic acid is substantially higher than that of its gaseous decomposition products (each mole of formic acid contains 9.2 kilocalories more energy than the reaction products). Thus, the reaction *could* theoretically occur. It *does* occur rapidly at room temperature when a catalyst (such as 1% palladium on activated carbon) opens a chemical pathway for the reaction to surge forward.

$$HCOOH \xrightarrow{\text{catalyst}} CO_2 + H_2.$$

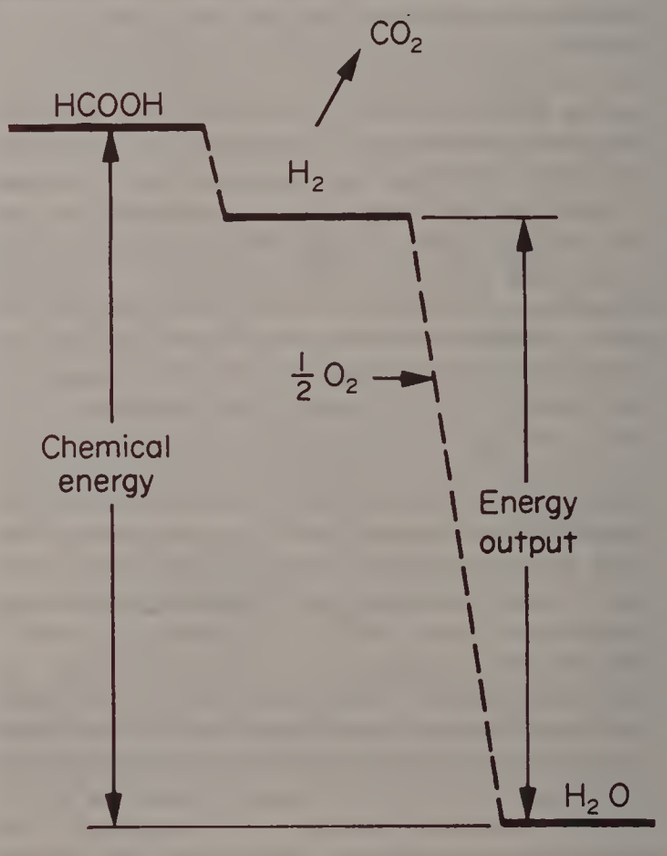
The Free Energy liberated by the reaction does not appear as heat (in fact, the reaction is slightly endothermic), but is dissipated as molecular disorder in the low-pressure gaseous products. This Free Energy can — in principle — be retained by collecting the gaseous product at very high pressure (about 1000 atmospheres), but this will probably not be feasible in actual practice. Therefore, we must accept an energy penalty of 9.2 kcal for each mole of hydrogen produced by the decomposition of formic acid. Since one mole of hydrogen provides 57 kcal of Free Energy when it is oxidized to water, we can utilize 86% of the energy content of formic acid.

The use of formic acid as a hydrogen carrier offers several outstanding advantages. Firstly, large-scale production of formic acid from coal, and its on-site conversion to hydrogen, could be carried out with available technology (although greater efficiency might be achieved by further technological improvements). Hydrogen produced by formic acid decomposition can be oxidized in a fuel cell, or burned in existing engines. In either case, water vapor would be the only produuct released to the environment. Each step in the coal-to-power conversion process could be carried out with virtually no emission of poisonous waste gases. Carbon dioxide would be the only product released to the atmosphere.

Even the discharge of carbon dioxide could be avoided in some energy storage systems by using alkaline aqueous solutions of formic acid (or rather, sodium formate). Then, carbon dioxide is not liberated as a gas, but is retained in the solution in the form of bicarbonate or carbonate ions. After releasing its hydrogen content, the solution could be "recharged" by applying hydrogen gas under pressure to reverse the reaction equilibrium.

We can thus use a formate/bicarbonate solution in closed-cycle energy storage and distribution systems. For example, formate/bicarbonate solution could be employed to transmit energy through a pipeline. Catalysts for the reversible conversion of formate and hydrogen would be located at both ends of the pipeline. The energy-transmitting station would react bicarbonate solution with hydrogen under pressure, and feed the resulting formate-enriched solution into a pipe. At the other end of the pipe, a reduction of pressure would cause the formate solution to release hydrogen. The hydrogen would then be oxidized to provide heat energy or electrical power. A pipeline carrying a flow of one cubic metre per second of formate solution (with a formate concentration of 10 Molar) would have an energy transmission capacity of three Megawatts. As well as being converted on-site to electricity, hydrogen can be used to provide Free Energy to synthesize many chemical products. Hydrogen is one of the most versatile reactants and Free Energy sources.

Further in the future, we can envision that the production of hydrogen in solar cells (by photodecomposition of water) will create a demand for hydrogen storage, which could be met by the formate/biocarbonate system. Let us consider application of such a system for space heating and cooking in a building equipped with photohydrogen solar cells. Hydrogen produced during sunny periods would be fed under pressure to a formate/bicarbonate solution, converting the bicarbonate ions to formate (until the concentration of formate reaches about 10 Molar). When sunlight is not available, hydrogen production ceases. As hydrogen continues to be oxidized to provide heat, the hydrogen pressure falls, causing additional hydrogen to be released by the decomposition of formate. The combustion energy of hydrogen released by one cubic metre of 10 Molar formate solution could provide 5 kilowatts of heat (a typical requirement for a family) for 3 days.



The products of formic acid decomposition, hydrogen and carbon dioxide, have 9.2 kilocalories less energy than one mole of formic acid. The Free Energy liberated by the reaction could—in principle—be recovered as useful work. Unfortunately, it will probably not be practical to utilize this energy, which thus represents a loss of 12% of the potentially useful energy content of formic acid. However, the chemical energy released by oxidation of hydrogen can be utilized very efficiently by a fuel cell.

One limitation in the use of formic acid as an energy storage intermediate or fuel is the modest amount of hydrogen which can be produced from each litre of formic acid. This shortcoming is especially significant for vehicle propulsion, in which the weight and volume of fuel are limited. Hydrogen constitutes only 4% of the weight of formic acid. While the hydrogen released by one litre of formic acid is about 5 times more than is normally contained in a tank of compressed gas of the same volume (at 100 atmospheres pressure), it provides only *one-eighth* the combustion energy of one litre of conventional hydrocarbon fuel.

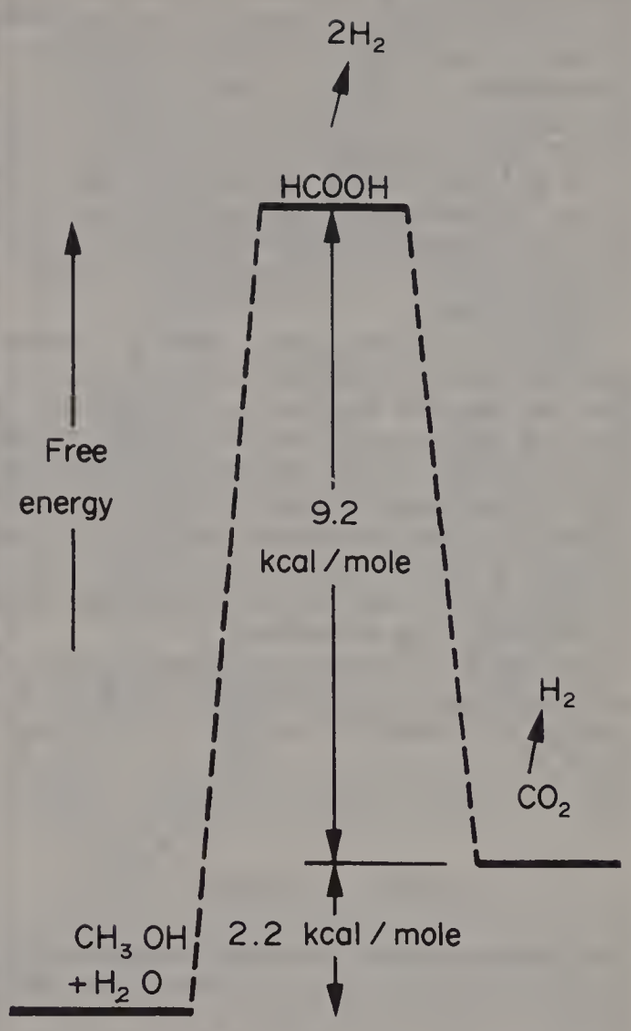
This low energy storage density suggests that a vehicle propelled by formic acid would need a very large fuel tank, or have very limited range. However, this limitation is not as severe as might be suggested. When formic acid evolves hydrogen, whose chemical energy is converted directly to electricity, a very large fraction of its energy content is utilized. Perhaps half the chemical energy in formic acid fuel could be converted to electricity, and then to mechanical power. The major energy conversion losses would already have been incurred in the production of formic acid from coal. By contrast, processing of conventional motor fuels is very efficient, but only 15 - 20% of the fuel's chemical energy is converted to mechanical power in the automobile engine.

Methanol appears to be a better chemical intermediate for the storage and release of hydrogen. Like formic acid, methanol is a stable liquid at room temperature. However, methanol has a higher energy content per unit volume — about half that of hydrocarbon fuels. Methanol contains, by weight, over 12% hydrogen (three times as much as formic acid). Decomposition of one mole of methanol liberates three moles of hydrogen by the following reaction, in which one mole of hydrogen is contributed by a reacting water molecule.

$$CH_3OH + H_2O \xrightarrow{\text{catalyst}} 3H_2 + CO_2.$$

It is important to note that, as in any reaction, the catalyst accelerates the decomposition *and* the formation of methanol. The direction in which the reaction proceeds depends upon the reaction conditions, and not the type of catalyst. For example, the commercial production of methanol (by reacting hydrogen and carbon monoxide with a metal oxide catalyst) is carried out at high pressure, in order to shift the reaction equilibrium towards the production of methanol.

The decomposition of methanol to hydrogen and carbon dioxide is opposed by a small Free Energy barrier (2.2 kcal/mole) at normal temperature. The reaction may proceed — in principle (that is, if a suitable catalyst is available) — by reducing the pressure of hydrogen and carbon dioxide to about 0.2 - 0.5 atmospheres. By removing additional hydrogen and carbon dioxide as they are formed, the reaction can be induced to form more of these gaseous products, despite the small Free Energy barrier. Once the hydrogen leaves the decomposition reactor, and is removed from contact with the catalyst, it can be compressed to whatever pressure is needed for fuel cell operation.



While formic acid has considerably more chemical energy than its decomposition products, this is not the case for methanol. The enzyme-catalyzed decomposition of methanol, which initially yields formic acid, is opposed by a small (2.2. kcal/mole) Free Energy barrier. Nonetheless, the reaction can proceed by allowing the gaseous products to escape from the reaction zone.

Hydrogen can be obtained from methanol at room temperature using microbial enzymes as catalysts. This allows virtually the entire chemical energy of methanol to be retained in the product hydrogen. The same enzymes could also be used to induce the decomposition of formic acid, as in fact, formic acid is an intermediate in the microbial break-down of methanol to hydrogen.

Enzymes for methanol decomposition can be derived from microorganisms which produce hydrogen from carboxylic acids (such as formic acid), and bacteria which oxidize hydrogen to water and produce methane. Such methylotrophic bacteria are used to produce "biogas" during anaerobic fermentation of organic waste. These microorganisms, and their enzymes, usually function at temperatures below 40°C and in neutral solution. A few bacteria are thermophilic, and function best at temperatures between 40° and 55°C. Enzymes of these bacteria are more robust, and might ultimately be utilized to produce biocatalysts that retain high activity for long periods.

As is characteristic of reactions carried out by

microorganisms, the microbial decomposition of methanol or formic acid proceeds in a series of steps. In each successive step, a dehydrogenase enzyme simultaneously oxidizes the substrate (forming carbon dioxide in the final step) and reduces a "cofactor". The reducing potential stored in the cofactor is eventually used to generate hydrogen from water. A hydrogenase enzyme (isolated from hydrogen-oxidizing bacteria) catalyzes the production of hydrogen, which regenerates the cofactor in its initial state.

Different methylotrophic bacteria contain dissimilar enzyme systems and use a variety of cofactors. For practical application, it is desirable to choose an enzyme system which uses the same cofactor in each stage of the reaction. One cofactor involved in the catalytic action of many enzymes is NAD^+ (nicotineamidadeninenucleotide). The mode of action of NAD^+ has been well studied, and we therefore sought to find a series of dehydrogenase enzymes which utilize this cofactor.

As a result, we isolated two dehydrogenase enzymes from yeast. One, alcohol dehydrogenase (E_A) catalyzes the oxidation of methanol to formic acid:

$$CH_3OH + H_2O + 2\,NAD^+ \xrightarrow{E_A} HCOOH + 2\,NADH + 2H^+.$$

The second enzyme, formatedehydrogenase (E_F), catalyzes the oxidation of formic acid to carbon dioxide:

$$HCOOH + NAD^+ \xrightarrow{E_F} CO_2 + NADH + H^+.$$

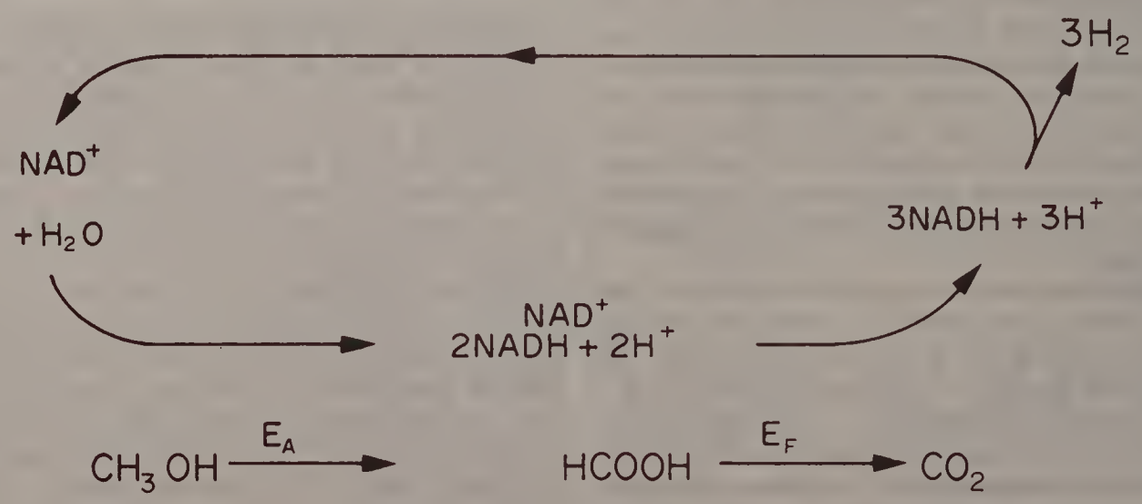
Of course, these reactions are of no practical value unless hydrogen can be recovered from the reduced NADH cofactor. This is accomplished with a hydrogenase enzyme (E).

$$NADH + H^+ \xrightarrow{E} NAD^+ + H_2.$$

By using a series of dehydrogenase and hydrogenase enzymes, the NAD^+ cofactor continuously circulates between the two enzyme systems and undergoes no net reaction. Thus, we can establish a room temperature reaction pathway for the production of hydrogen from methanol or formic acid. The main practical limitation is the high cost of the enzymes and cofactors. However, the application of new techniques now allows us to regenerate and reuse these biomolecules for thousands of reaction cycles.

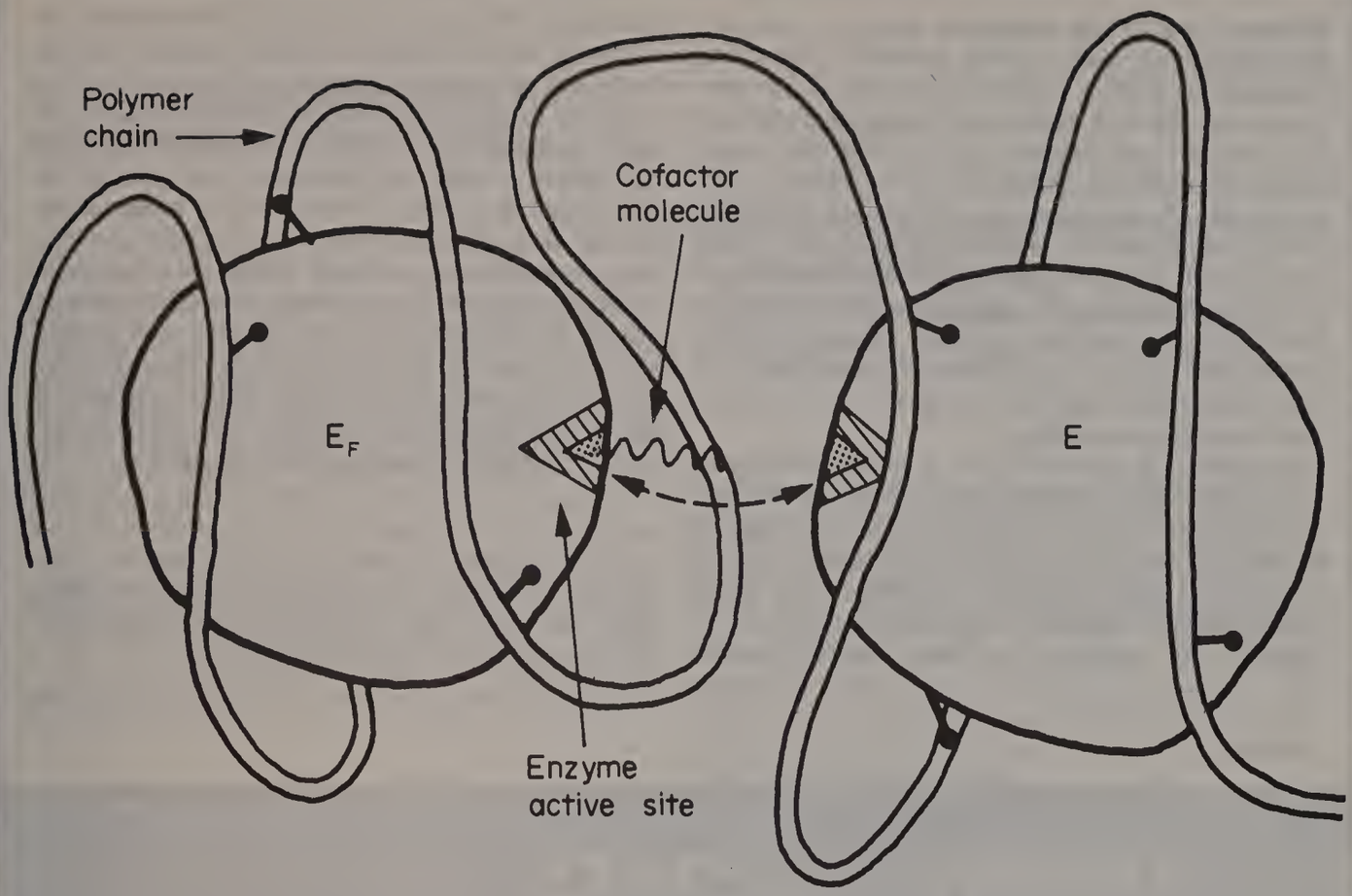
Unless NAD^+ or other cofactors were bound to a surface or macromolecule retained within the reactor, they would be washed away with the reaction products. Unbound cofactors have a molecular weight in the range of 300 - 500, and are not much larger than molecules consumed/formed in the reaction. Cofactors may be immobilized within the reactor by crosslinking the cofactor molecule to a high molecular weight soluble polymer (dextran, for example) or to a solid carrier (such as Sepharose). Using such immobilization methods, we have been able to utilize cofactors for up to 10 000 reaction cycles. Good results have also been attained by absorbing an unmodified cofactor on the packing of a column reactor. The immobilization of cofactors and enzymes is now widely applied to many enzyme-catalyzed reactions. Several review articles have been published describing the various immobilization methods that have been devised.

A promising new technique, developed by ourselves, yields self-contained catalyst systems for the generation of hydrogen. These "chimera" molecular species are formed by joining biomolecules from different organisms. Two enzymes (a dehydrogenase and hydrogenase) are immobilized within the structure of a polymer chain, and a cofactor is attached (with a long segment of the molecule acting as a spacer) so that it can interact with active sites on both



Microbial enzymes (E_A and E_F) oxidize methanol to formic acid, and then to carbon dioxide. During each step, the enzyme reduces the NAD^+ cofactor to NADH. A hydrogenase enzyme later breaks down the NADH, liberates hydrogen gas and regenerates the cofactor.

Like the other reaction steps, the initial oxidation of methanol is reversible. By itself, it will not advance to a significant extent, since the reaction's Free Energy does not favor the formation of the products. However, the reaction equilibrium is pulled forward by consumption of formic acid and escape of hydrogen gas.



Self-contained bio-catalysts for hydrogen production are made by binding enzymes within the structure of a polymer chain, so that a molecule of NAD^+ cofactor can interact with the active site of two enzymes. This diagram depicts a biocatalyst system for the decomposition of formic acid. A molecule of NAD^+ cofactor is shown being reduced at the active site of a formate dehydrogenase enzyme (E_F). Subsequently, the cofactor will interact with the active site of a hydrogenase enzyme (NADH-dehydrogenase, E), release hydrogen, and be restored to its initial state.

enzyme molecules. By immobilizing such enzyme/cofactor systems on solid porous carriers, we can make heterogenous catalysts which continuously produce hydrogen when in contact with a stream of methanol or formic acid.

An important consideration is the stability of enzyme catalysts under conditions at which they are to be used. Immobilizing the enzyme on the surface of a solid carrier imparts rigidity to the enzyme molecule and largely prevents unfolding of its protein structure. This is achieved by crosslinking chemical groups on the enzyme molecule and the solid surface with a bifunctional reagent. In this way, the useful lifetime of the enzyme can be greatly increased.

Immobilizing the enzyme also reduces its vulnerability to inactivation by chemical oxidation. Entrapment of the enzyme in a polymer matrix creates a protective microenvironment around the enzyme active site. By binding formatedehydrogenase to a film of polyvinylpyridine, for example, we were able to considerably extend the useful life of the enzyme.

In some cases, biocatalysts may be prepared by immobilizing entire cells (containing all necessary enzymes and cofactors) in a supporting structure. However, only by isolating individual enzymes can biochemical systems be tailored to catalyze one specific reaction.

It might prove possible to prepare biocatalysts with enhanced enzyme stability and catalytic efficiency by utilizing more elaborate enzyme systems. Systems containing several cofactors would likely be more efficient in utilizing energy liberated by the decomposition of methanol or formic acid, and transferring it to a hydrogen-producing enzyme.

Many hydrogenases function very well with cofactors of the methylviologen type. Methylviologen has a reduction potential nearly equal to that of the $NAD^+/NADH$ pair, and consequently, methylviologen is readily reduced by NADH. It acts as a one-electron energy carrier, transferring the reducing potential of the $NAD^+/NADH$ system to hydrogenase for the production of hydrogen from hydronium ions. This cofactor can be used with a wide range of hydrogenase enzymes, including some very stable and catalytically active hydrogenases found in thermophilic bacteria. Methylviologen itself is stable in oxidized and reduced form, is highly soluble, and does not undergo irreversible changes during electrochemical oxidation. The oxidation and reduction of methylviologen is catalyzed by the enzyme diophorase, which is contained in large amounts in cells of various organisms.

Energy carriers of the methylviologen type could ultimately be used in biochemical fuel cells — producing electricity directly from the oxidation of methanol or formic acid (and thus, eliminating the need for hydrogen to be produced as an intermediate). Unlike NADH, methylviologen is very active electrochemically. Rather than utilize the reducing potential stored in NADH to liberate

hydrogen gas (from hydrogen ions in solution), methylviologen could provide electrons directly to the anode of an electrochemical fuel cell. At this electrode, reduction of water would generate hydroxide ions and provide electrons to the external circuit. Electrons would be accepted by the cathode of the same cell, where oxygen gas reacts with hydroxide ions (forming water). Our studies have shown that formic acid could be electrochemically oxidized on graphite electrodes (in the presence of NAD^+, methylviologen, and the enzymes formatedehydrogenase and diaphorase). Previous experiments by other researchers required the use of platinum or platinum-alloy electrodes.

Ultimately, it may be possible to make biochemical systems in which electrons are transferred directly from the active site of an enzyme to an electrode. It has already been shown that a hydrogenase enzyme immobilized in a semiconducting matrix can bring about hydrogen oxidation on a graphite electrode — without any cofactors or other energy-transfer mediators. We can envisage that biochemical fuel cells using single enzyme or enzyme systems may be developed to produce electricity directly from the oxidation of methanol. The feasibility of such fuel cells is indicated by the existence of microorganisms that subsist entirely on methanol. Methanol is the only energy and carbon source used to maintain the cells of these bacteria and to synthesize protein. These organismms are now being modified with recently-developed genetic engineering techniques to provide an alternative source of food and animal feed (and thus, establish a chemical route to make food from coal). Perhaps the same biochemical systems in these organisms can be redirected to oxidize methanol and produce electric power.

Acknowledgement:
The authors express their sincere gratitude to Professor G. L. Gal'chenko for his comprehensive assistance in undertaking thermodynamic calculations.

RECENT REPORTS

Abbreviated terminology of Oligosaccharide chains (*Provisional*)

After a review of trivial systematic names, symbols are given for specifying sugars, uronic acids, deoxysugars, aminodeoxysugars, anhydrosugars, etc. The mode of linkage is then specified for unbranched and branched oligosaccharides, and the method of indicating substitution and branching is given. An appendix gives a condensed system of symbolism. Many examples are given, e.g. amygdalin is represented as ß-D-Gle*p*-(1 6)-ß-D-Glc*p*-0-CH (CN)Ph in the full system and as G1c(ß1-6)G1c (ß)-0-CH(CN)Ph in the condensed system.

The report, prepared by the IUB - IUPAC Joint Commission on Biochemical Nomenclature, will be published in *Pure & Applied Chemistry,* in late 1981.

Polysaccharide nomenclature *(Provisional)*

Generic names such as polysaccharide are first defined, and then the use of the ending 'an' as in glucan, glucuronan, etc. The naming of polysaccharides containing aminodeoxysugar residues is described. Conventions are specified for heteropolysaccharides, which contain two or more kinds of sugar residue, so that the name can indicate features such as a backbone of a single type of residue. Methods of indicating substituents are also given.

The report was prepared by the IUB - IUPAC Joint Commission on Biochemical Nomenclature, and will be published in *Pure & Applied Chemistry* in late 1981.

Radiation sources

Part V — Nomenclature, symbols units and their usage in spectrochemical analysis (*Provisional*)

Radiation sources are fundamental to the application of spectrochemical analytical methods and there has long been a need for uniformity in the description of these sources and their functions. This need has been underlined in recent years when several new types of sources have been developed and new words have been coined sometimes in conflict with other accepted terms. A difficulty which faced the Commision V-4 was the way in which such radiation sources could be classified i.e. by the type of radiation emitted, by their operation or by their application characteristics. Eventually, for practical purposes, the classification was made on the operating pressure and the type of radiation emitted. Preference was given to those sources used for analytical atomic spectroscopy which includes arcs, sparks, radiofrequency and microwave plasma, low pressure electrical discharges in gases, and laser sources. This preference was made because other radiation sources (e.g. for X-ray, molecular spectroscopy etc) are dealt with or shall be dealt with, in other documents.

The report was prepared by the Commission on Spectrochemical and other Optical Procedures for Analysis, and will be published in *Pure & Applied Chemistry* in late 1981. Comments may be addressed to the Commission Secretary; Dr. R. Jenkins, Philips Electronic Instruments Inc., 85 McKee Drive, Mahwah, New Jersey 07430, USA.

Nomenclature of branched-chain monosaccharides (Provisional)

The naming of acyclic forms is described, and the first part of this is the rules for choosing which is the parent chain. This leads to naming the parent monosaccharide, including the naming of the *C*-substituent that forms the branch. Stereochemical conventions have to be extended to specify configuration: the two substituents at one carbon on the parent chain are put in order of priority; that of higher priority is considered to replace hydroxyl and that of lower priority to replace hydrogen in assigning a name to the parent monosaccharide. Equivalent groups and terminal substitution are dealt with separately. Cyclic forms are then described. Many examples are given .

The report was prepared by the IUB - IUPAC Joint Commission on Biochemical Nomenclature, and will be published in *Pure & Applied Chemistry* in late 1981.

Conformational nomenclature for five-and six-membered ring forms of monosaccharides & their derivatives *(Provisional)*

The system for designating six-membered ring-forms of monosaccharides as chair *(C)*, boat *(B)*, skew *(S)* and half-chair (*H*) forms is described, including the symbolism, e.g. $^{1}C_{4}$. In this symbolism a superscript before the letter means displacement of the atom indicated to the side from which the numbering of the ring appears clockwise, and a subscript after the symbol means displacement of the atom indicated to the opposite side. Five-membered rings are similarly described as envelope (*E*) and twist (*T*) forms. Several examples of conformations are illustrated.

This report, prepared by the IUB - IUPAC Joint Commission on Biochemical Nomenclature, will be published in *Pure & Applied Chemistry,* Vol. 53, No. 10 (1981).

Nomenclature of unsaturated monosaccharides (*Provisional*)

Recommendations are given for naming unsaturated monosaccharides. Double bonds are indicated with the suffix en and its use is described. Triple bonds and cumulative double bonds require deoxy prefixes to convert sugars into derivatives on which the operator dehydro can indicate double and triple bonds.

The report was prepared by the IUB - IUPAC Joint Commission on Biochemical Nomenclature, and will be published in *Pure & Applied Chemistry* in late 1981.

Physico-chemical quantities and units in clinical chemistry with special emphasis on activities & activity coefficients (*Provisional*)

In Clinical Chemistry several quantities which directly or indirectly refer to the activity of the components are routinely employed, e.g. pH, partial pressure of blood gases, osmolality of blood and urine. In the future, activity measurements by means of ion selective electrodes will become daily routine. The results of activity measurements may be expressed in a variety of ways, e.g. chemical potential, relative activity, fugacity; and relative activity may furthermore be either rational or based on molality or substance concentration.

A need was therefore felt for a recommendation concerning the preferred way of expressing the results of activity measurements for clinical chemical purposes.

The activity of hydrogen ions is preferably expressed in terms of pH, defined as the negative logarithm of the relative (molal) activity of hydrogen ions, and measured with a H^+-selective electrode. The pH values of the primary calibration standards are measured by means of the Harned cell using the Bates-Guggenheim convention for the molal activity coefficient of the chloride ion.

The activity of other ions (e.g. Na^+,K^+,Ca^{2+}) is preferably expressed in terms of the substance concentrations of free ion or component, calculated from the measured activity by means of the appropriate activity coefficient.

The activity of blood gases is preferably expressed as the partial pressure of the gases in an ideal gas mixture in equilibrium with the blood.

The activity of water is preferably expressed as the osmotic concentration, defined as the negative natural logarithm of the activity of the water and divided by the molar volume of pure water.

A list of definitions of the different quantities has been compiled, and some equations relating the different quantities are given in the remarks column. A list of typical values for activities and activity coefficients for the components H^+,Na^+,K^+,Ca^{2+}, $C0_2$,0_2 and H_20 for normal human plasma is given.

This 38 page report was prepared by O. Siggaard-Andersen, R. A. Durst and A. H. J. Maas for the Commission on Quantities and Units in Clinical Chemistry, and was published in *Pure & Applied Chemistry,* Vol. 53, No. 8 (1981), pp. 1605 - 1643.

Chemical nomenclature:

Where to find that name, symbol or unit that you're looking for

Rules for naming, symbolizing and representing chemical compounds have been published in various journals, leaflets and books. IUPAC has compiled much of this information into a few major reference books, but much remains dispersed in the chemical literature. Chemical nomenclature changes constantly, and it is necessary to publish revisions and additions separately (usually, in the IUPAC journal *Pure & Applied Chemistry*). Other nomenclature reports — recommending terminology, symbols and units for reporting of results — deal with a diverse range of subjects. Collecting such reports into a few subject areas is not always possible or practical — although that is precisely what is attempted here.

The following listing is intended to be a comprehensive compilation of all chemical nomenclature published in recent years. It is presented in two main sections. The first deals with nomenclature of chemical compounds. These are subdivided into Analytical Reagents, Biochemical Compounds, Inorganic Substances, Organic Compounds, and Polymers. The second contains terminology, symbols, units and recommendations for presentation of results. These are divided into General Terminology, Terminology for Chemical Analysis, and Terminology for Spectroscopic Techniques.

Reproduction of the nomenclature listing (in whole or part) is permitted, provided that *Chemistry International* is acknowledged as its source.

NOMENCLATURE OF CHEMICAL COMPOUNDS

I. Analytical Reagents

Guide to Trivial Names, Trade Names and Synonyms for Substances used in Analytical Chemistry, *Pure & Appl. Chem.*, Vol. 50, No. 4 (1978) pp. 339 - 370.

II. Biochemical Compounds

AMINO ACIDS AND DERIVATIVES

***Nomenclature of Amino Acids (Provisional Nomenclature Appendix No. 46, September 1975).**

***Symbols for Amino Acid Derivatives and Peptides (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 315 - 331).**

BIOCHEMICAL EQUILIBRIUM

***Recommendations for measurement and presentation of Biochemical Equilibrium Data (Provisional Nomenclature Appendix No. 61, July 1977, *Info. Bull.*).**

CARBOHYDRATES & SUGARS

Conformational Nomenclature for Five and Six-Membered Ring Forms of Monosaccharides and Their Derivatives (Provisional) (*Pure & Appl. Chem.*, Vol. 53, No. 10, 1981 and also in the *Eur. J. Biochem*, 111, 295 - 298, 1980).

Abbreviated Terminology of Oligosaccharide Chains (Provisional) (to be published in late 1981 in *Pure & Appl. Chem.* and *J. Biol. Chem.*).

Polysaccharide Nomenclature (Provisional) (to be published in late 1981 in *Pure & Appl. Chem.* and *J. Biol. Chem.*).

Nomenclature of Unsaturated Monosaccharides (Provisional) (to be published in late 1981 in *Pure & Appl. Chem.* and *Eur. J. Biochem.*).

Nomenclature of Branched-chain Monosaccharides (Provisional) (to be published in late 1981 in *Pure & Appl. Chem.* and *Eur. J. Biochem.*).

ENZYMES

Enzyme Nomenclature (1978), published by Academic Press in hardcover and softcover editions. First supplement in *Eur. J. Biochem.*, 104, 1 - 4, 1980. Second supplement published in *Eur. J. Biochem.*, 116, 423 - 435, 1981.

LIPIDS

***Nomenclature of Lipids (Provisional Nomenclature Appendix No. 67, December, 1977).**

NUCLEIC ACIDS

***Abbreviations and Symbols for Nuclei Acids, Polynucleotides and their Constituents (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 277 - 290).**

PHOSPHOROUS COMPOUNDS

*Nomenclature of Phosphorous-containing Compounds of Biochemical Importance (Provisional Nomenclature Appendix No. 66, December 1977).

PROTEINS & PEPTIDES

*Nomenclature of Peptide Hormones (Provisional Nomenclature Appendix No. 48, September 1975).

*Abbreviations and Symbols for the Description of Conformation of Polypeptide Chains (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 291 - 308).

*Abbreviated Nomenclature of Synthetic Polypeptides (Polymerized Amino Acids) *Pure & Appl. Chem.*, Vol. 33, Nos. 2 - 3, 1973, pp. 437 - 444).

Nomenclature of Iron-Sulfur Proteins (*Eur. J. Biochem.*, 93, 427 - 430, 1979; corrected in *Eur. J. Biochem.*, 102, 315, 1979).

*A One-letter Notation for Amino Acid Sequences (*Pure & Appl. Chem.*, Vol. 31, No. 4, 1972, pp. 639 - 645).

Rules for Naming Synthetic Modifications of Natural Peptides (*Pure & Appl. Chem.*, Vol. 31, No. 4, 1972, pp. 647 -653).

VITAMINS

*Nomenclature for Vitamin B-6 and Related Compounds (*Pure & Appl. Chem.*, Vol. 33, Nos. 2 - 3, 1973, pp. 445 -452).

*Also published in "Biochemical Nomenclature and Related Documents", 1978, a 220 page softcover manual published for The Biochemical Society for IUB (available from the Biochemical Society Book Depot, P.O. Box 32, Commerce Way, Colchester, Essex C02 8HP, England).

III. Inorganic Substances

ACIDS

Chapter 5 of "Nomenclature of Inorganic Chemistry".*

ADDITION COMPOUNDS

Chapter 8 of "Nomenclature of Inorganic Chemistry".*

BORON COMPOUNDS

Nomenclature of Inorganic Boron Compounds (*Pure & Appl. Chem.*, Vol. 30, Nos. 3 - 4, 1972, pp. 681 - 710).

CARBON

International cooperation on characterization and terminology of carbon and graphite. (*Pure & Appl. Chem.*, Vol. 51, No. 7, 1979, pp. 1561 - 1574).

COORDINATION COMPOUNDS

Chapter 7 of "Nomenclature of Inorganic Chemistry".*

CRYSTALLINE PHASES

Chapter 9 of "Nomenclature of Inorganic Chemistry".*

ELEMENTS

Recommendations for the Name of Elements of Atomic Numbers Greater than 100 (*Pure & Appl. Chem.*, Vol. 51, No. 2, 1979, p. 381)

Chapter 1 of "Nomenclature of Inorganic Chemistry".*

IONS & RADICALS

"How to name an Inorganic Substance", the companion guide to the use of "Nomenclature of Inorganic Chemistry".

ISOTOPICALLY-MODIFIED COMPOUNDS

Nomenclature of Inorganic Chemistry. Part II.1. Isotopically-modified compounds. (*Pure & Appl. Chem.*, Vol. 53, No. 10, 1981).

NITROGEN

Nomenclature of Hydrides of Nitrogen and Derived Cations, Anions and Ligands (*Info. Bull.*, No. 2, 1978).

POLYANIONS

Chapter 4 of "Nomenclature of Inorganic Chemistry".*

SALTS

Chapter 6 of "Nomenclature of Inorganic Chemistry'.*

ZEOLITES

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ALDEHYDES & KETONES

Section C of "Nomenclature of Organic Chemistry".*

CARBOXYLIC ACIDS

Section C of "Nomenclature of Organic Chemistry".*

CAROTENOIDS

Nomenclature of Carotenoids (*Pure & Appl. Chem.*, Vol. 41, No. 3, 1975, pp. 405 - 431).

COORDINATION COMPOUNDS

Section D of "Nomenclature of Organic Chemistry".*

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Nomenclature of Cyclitols (*Pure & Appl. Chem.*, Vol. 37, Nos. 1 - 2, 1974, pp. 283 - 297).

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STEREOCHEMISTRY

Section E of "Nomenclature of Organic Chemistry".*

STEROIDS

Nomenclature of Steroids (*Pure & Appl. Chem.*, Vol. 31, Nos. 1 - 2, 1972, pp. 283 - 322).

SULFUR-CONTAINING COMPOUNDS

Section C of "Nomenclature of Organic Chemistry".*

TETRAPYROLES

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Section A: Hydrocarbons.
Section B: Fundamental Heterocyclic Systems.
Section C: Characteristic Groups containing carbon, Hydrogen, oxygen, nitrogen, halogen, sulfur, selenium and Tellurium.
Section D: Organic Compounds containing elements that are not exclusively carbon, hydrogen, oxygen, nitrogen, halogen, sulfur, selenium and tellurium.
Section E: General Principles for the naming of natural products and related compounds.
Section H: Isotopically modified compounds.

V. Polymers

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Sterochemical definitions and notations relating to polymers (*Pure & Appl. Chem.*, Vol. 53, No. 3, 1981, pp. 733 - 752).

List of Standard Abbreviations (Symbols) for Synthetic Polymers and Polymer Materials (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 473 - 476).

Basic Definitions of Terms Relating to Polymers (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 477- 491).

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PHYSICOCHEMICAL QUANTITIES AND UNITS

Manual of symbols and Terminology for Physicochemical Quantities and Units. (*Pure & Appl. Chem.*, Vol. 51, No. 1, 1979, p. 1.). (Also available from Pergamon Press as a 40 page softcover booklet.)

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*Terminology for Scales of Working in Microchemical Analysis (*Pure & Appl. Chem.,* Vol. 51, No. 1, 1979, p. 43).

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*Recommendations on the Usage of the Terms "Equivalent" and "Normal" (*Pure & Appl. Chem.,* Vol. 50, 1978, pp. 325 - 338).

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*Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis — Part III. Analytical Flame Spectroscopy and Associated Non-Flame Procedures (*Pure & Appl. Chem.,* Vol. 45, No. 2, 1976, pp. 105 - 123).

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X-RAY SPECTROSCOPY

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*Also published in the "Compendium of Analytical Nomenclature", (1978), a hardcover volume available from Pergamon Press.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1982

SAFE USE OF SOLVENTS

March 23—27. International Symposium on the Safe Use of Solvents. Brighton, UK.
(Mr. S. G. Luxon, Health & Safety Executive, 25 Chapel Street, London NW1 4DT, UK.)

CLINICAL CHEMISTRY

April 19—22. International Congress on Automation in Clinical Laboratory. Barcelona, Spain.
(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clinicos, C. S. "Principes de Espana", Hospitalet de Llobregat, Barcelona, Spain.)

PHYSICAL ORGANIC CHEMISTRY

July 11—16. 6th IUPAC Conf. on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, 1348 Louvain-la-Neuve, Belgium.)

MACROMOLECULES

July 12—16. IUPAC Macromolecular Symposium. Amherst/Mass., USA.
(James C. W. Chien, Dept. of Polymer Science & Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA.)

SELECTIVE POLYMER SORBENTS

July 19—22. 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.
(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 16206 Prague 616, Czechoslvakia.)

NATURAL PRODUCTS

August 2—7. 13th Int. Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs. Jeanne Beck, Symposium Secretariat—S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa.)

ORGANIC SYNTHESIS

August 22—27. 4th International Conference on Organic Synthesis. Tokyo, Japan.
(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.)

COORDINATION CHEMISTRY

August 23—27. 22nd Int. Conf. on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010, Hungary.)

PESTICIDE CHEMISTRY

August 29—September 4. 5th Int. Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2—1 Hirosawa Wako-shi Saitama Pref 351, Japan.)

MYCOTOXINS AND PHYCOTOXINS

August 31—September 2. 5th Int. IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Head, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30^2, DK-2100 Copenhagen 0, Denmark.)

THEORETICAL CHEMISTRY

September. International Symposium on Theoretical Organic Chemistry. Durbrovnik, Croatia, Yugoslavia.
(Dr. Ante Graovac, Institute "R. Bosković", POB 1016, 41001 Zagreb, Yugoslavia.)

CHEMICAL THERMODYNAMICS

September 7—10. 7th International Conference on Chemical Thermodynamics. London, UK.
(Prof. M. L. McGlashan, Department of Chemistry, University College London, 20 Gordon Street, London WC1H 0AJ, UK.)

CHEMISTRY RELATING TO AGRICULTURE

December 6—10. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington, D.C. 20036, USA.)
Note change in date.

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to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

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Chemistry International

IUPAC

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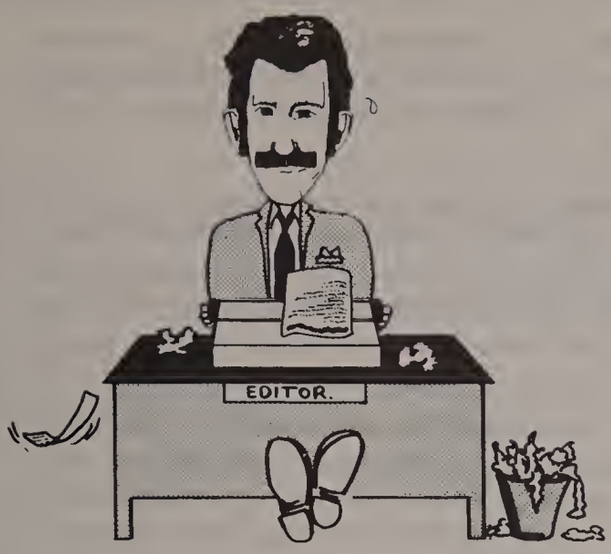

THE EDITOR'S DESK

Opinions expressed here are those of the author, and do not necessarily reflect the views or policy of IUPAC.

A chemist's "call-to-arms"

Bryant Rossiter, Chairman of IUPAC's CHEMRAWN Committee, presented a plenary lecture at the American Chemical Society's Autumn Meeting immediately before he flew to Belgium to attend the 31st IUPAC General Assembly in Belgium. Here, slightly abridged, is what he said.

Widespread hunger and malnutrition are among the tragedies of our time. The recent preliminary report of the *Presidential Commission on World Hunger* states that, "At least one out of every eight men, women and children on the earth suffer from malnutrition severe enough to shorten life, stunt physical growth and dull mental ability." The Food and Agricultural Organization of the United Nations estimates that as of 1975 approximately 450 million people—twice the population of the United States—were eating less than their minimum energy requirements.

As the population of the world expands from more than 4 billion in 1980 to an estimated 6 billion by the year 2000, the problem will worsen. Given present population growth and trends, eight of every ten people will live in a developing nation, and many of them will migrate to urban centers where food is not grown. Nearly 3,500 cities of a million or more inhabitants will have to be supplied.

Among the barriers to a clear and logical approach to the problem is the tendency of many scientists to consider only the technical aspects. This is understandable since we are technical people. Nonetheless, it is essential that we learn to treat problems of hunger and malnutrition as part of a system taking into consideration the social, economic, environmental, and political factors as well as the technical components involved.

In India, for example, 400 million people do not have enough to eat. The answer, some say, is to increase food production. This will help. But, the primary cause of hunger in India and most other parts of the world is not the lack of food but the lack of money to buy food. India, thought by many to have serious food deficits, reached cereal grain self-sufficiency in 1977, and exported one percent of its crops in 1978 - 1979.

Others say hunger can be alleviated by increasing the efficiency of each step in food production. This will help; however, increased efficiency often results in an even greater stress—increased unemployment and social unrest.

Birth control is the only answer some say. Perhaps, but the New York Times reported one week ago that "Virtually all authorities on world hunger agree that the problem is not due to overpopulation." The world's three most densely populated nations—Singapore, The Netherlands, and Japan—have no serious food problems.

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My point is this: Before we can solve the problems of hunger and malnutrition, we must first place the various factors in perspective. We must not indulge in generalizations that in the long term retard technical solutions, delay economic policy, and impede political action.

Today most of the problems of hunger and malnutrition reside in the developing world, yet nearly 95 percent of all research and development having the potential to solve these problems is done in the developed countries. Obviously technology transfer in some form must occur. But how technology is transferred is vitally important. Often in the past we went to third world countries to teach them what we know. In some cases, this has been successful. In others, it has not.

In the future we need to stimulate meetings, forums, and exchange where those from the advanced countries become the students and those from developing nations the teachers. In this environment, we can together better devise technical solutions to meet the needs of the developing countries within the context of *their* societies, *their* systems, *their* resources and *their* environments.

Those of us blessed to live in prosperous countries can be thankful that relatively few of our numbers are among the undernourished of the earth. We have never experienced the massive famines throughout history that have driven many to our shores. Still, we are not immune to the problems of hunger in other lands.

Let me quote again from the report of the Presidential Commission on World Hunger: "Global interdependence on food means that two straight years of bad harvest in any one of the major grain-producing nations of the world could precipitate another food crisis like the one that occurred in 1972 - 1974. Recurrent crises of this nature could bring widespread famine and political disorder to the developing countries and would severely disrupt a fragile world economy already weakened by energy shortages and rampant inflation. Policies of those in the developed countries will have a major role in determining whether or not this scenario will be played out."

Application of chemistry in the form of new fertilizers, pesticides, growth promoters, and dietary supplements were among the very things that made the first "green revolution" possible. However, many leading authorities recognize that much of present agricultural and food technology will soon be fully utilized and that the breakthroughs that led to the "green revolution" will be inadequate to meet increasing nutritional needs in the future.

Chemists within the developed nations are in a particularly favorable position to contribute to the next revolution because so much of the world's knowledge and technological base resides here. Moreover, more than 90 percent of this base has been generated in our lifetime and it is increasing at an accelerating rate.

In many ways chemistry and agriculture have developed along parallel or independent paths. The time is now ripe for a strong synergism between the chemical and agricultural sciences. Indeed this is the rationale behind CHEMRAWN II, The International Conference on Chemistry and World Food Supplies—the New Frontier, scheduled for Manila, Philippines, December 6 - 10, 1982. This meeting is a chemists "call to arms." It is the first, major international, interdisciplinary conference to bring together scientists and decision makers from governments, industry and academia for the express purpose of developing research directions and priorities designed to meet the mounting food problem. Leaders within the International Union of Pure and Applied Chemistry invite your interest and participation in this important event. In many ways Chemrawn II will point wither and whence we as chemists go next.

Simplified chemical tests can support medical services in remote areas

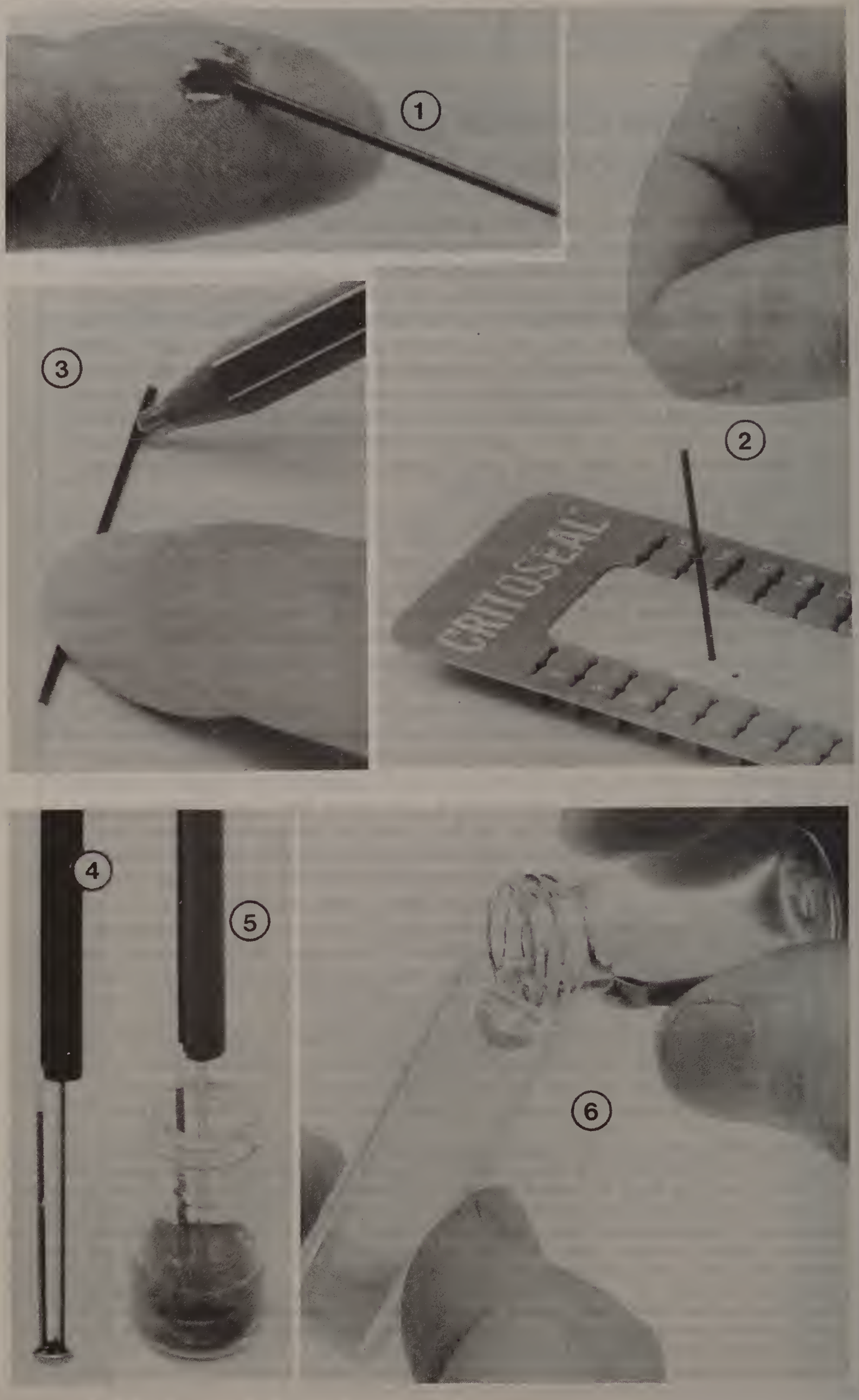
The trend in clinical chemistry analysis has been to centralise laboratory testing within a few hospital centres equipped with very sophisticated and expensive instruments. As a result, medical practitioners in small towns, villages and rural communities must send their patients long distances to major hospitals for chemical tests, or wait days for test results. Many are now questioning the policy of concentrating clinical chemistry testing within major centres. A great deal of time could be saved and inconvenience avoided if a few selected clinical tests could be performed at local clinics, doctor's surgeries and blood transfusion centres. With results of a few common tests available within an hour, general practitioners could diagnose many disorders and, in other cases, could decide immediately that further tests or transfer to a hospital were warranted.

The availability of simple, easy-to-use equipment and reagents for conducting clinical chemical analysis would thus be a great aid to the medical practitioner on "the front line" of medicine. In some places—the Australian outback, Innuit communities in Northern Canada, and much of Africa and Asia—that front line is very far indeed from major medical centres. There, the medical doctor may be virtually on his own, without the benefit of even the most basic clinical tests to help him investigate the cause of an illness or to assess the effectiveness of a treatment.

We can expect that increasingly complex and expensive equipment will continue to be developed to perform a greater variety of clinical tests, and perform them more rapidly. At the same time, new technology is making possible the introduction of simple, cheap equipment and reagents that will allow doctors and their assistants to perform a few most-needed clinical tests. This equipment, unlike its big-sister multichannel analyzers at the other end of the clinical chemistry spectrum, is intended to be used by personnel with relatively little clinical chemistry training, in the most adverse climates and conditions. The first prototype units are beginning to accompany health workers bringing modern medicine into mountains, deserts and rainforests in Algeria, Pakistan, Nepal, Burma and Papua New Guinea. These pioneers are bringing clinical chemistry analysis beyond frontiers where it has never gone before.

When a development team at the Clinical Research Centre (in London, UK) set out to design a low-cost system to provide test results for medical workers in developing countries, they were entering an unexplored area. They hoped to base their system on colorimetric reagents that were already available and widely used. These compounds react with specific components in blood to form intensely-coloured complexes. No one knew whether these reagents could tolerate prolonged exposure to heat and humidity without decomposing or losing efficacy.

Even if they were, no suitable colorimeter was available to measure the light absorption by the reagent - substrate complex, and convert this directly to the concentration of the component being analyzed. The colorimeter would need to be compact and portable. It would likely receive considerable buffeting (as it might often be carried in a Land Rover or backpack), would need to operate for extended periods with little maintenance and no repairs, and could be subjected to extreme weather conditions. A few commercially-available colorimeters were self-contained and simple-to-use, but none were low in cost or suitable for field use in tropical countries. For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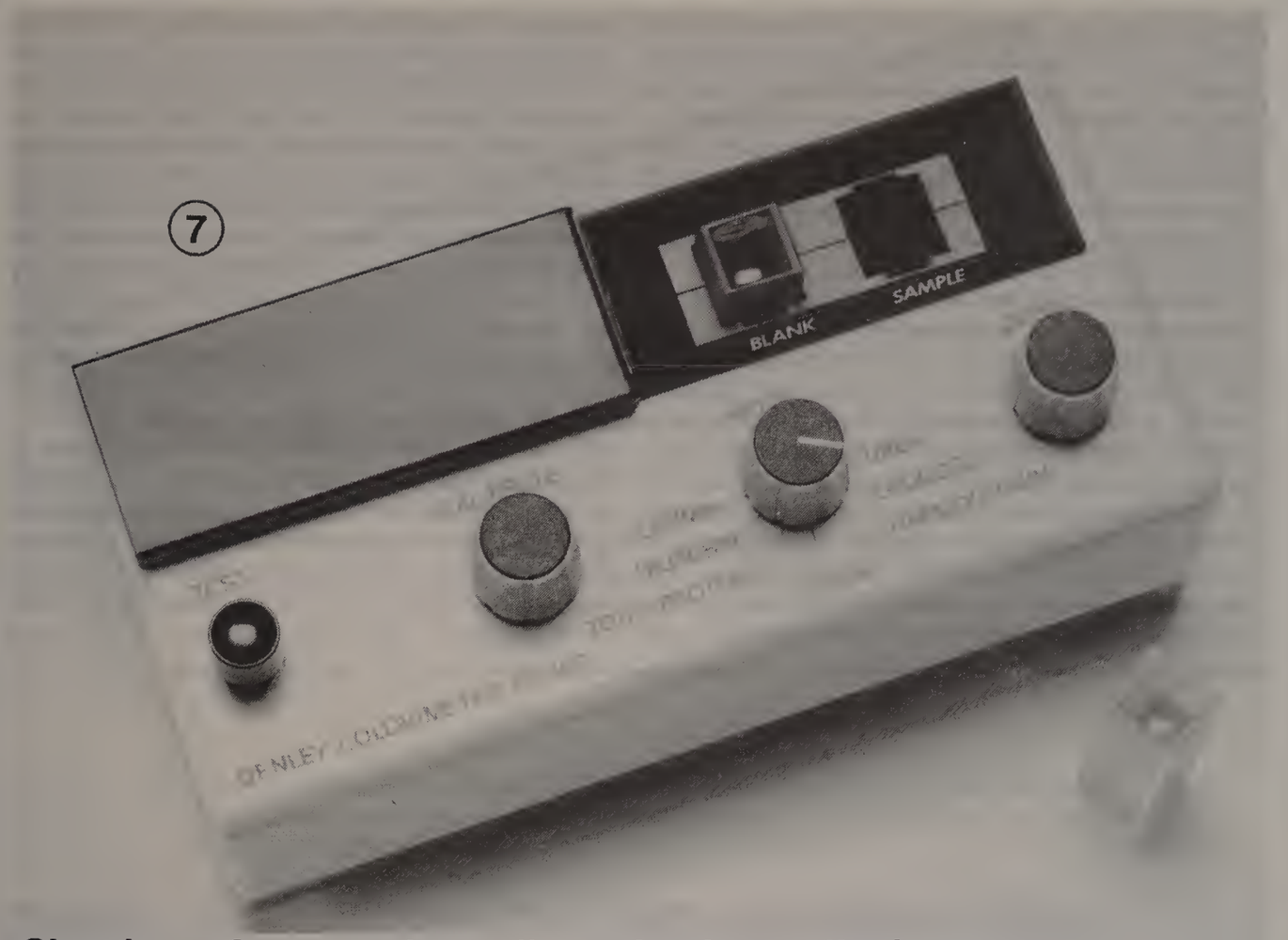


Simple, safe procedure allows basic medical tests in isolated areas and difficult field conditions

A drop of blood for one or more chemical analyses may be obtained by pricking the patient's finger with a sterile, disposable lance. The blood is drawn into a glass capillary tube by capillary action (1), and the tube is then plugged at one end with plastic putty (2). Near the opposite end, the tube is cut so that the column of blood (or blood serum, after centrifugation) comes flush to the end of the tube (3). An exact volume of 10, 20 or 25μL is displaced when the open end of the tube is slid over a thin rod projecting from the base of the microsampler "Swizzlestick"*(4). The rod fits snugly inside the capillary tube, squeezing out the desired volume of fluid.

The displaced droplet of blood is washed off as the Swizzlestick is swirled in a prepackaged reagent solution (5). The reagent solution forms a coloured complex with the blood component being analyzed, and is poured into a sample cell (6). Light absorption by the sample solution is then measured in a compact battery-powered colorimeter, specially designed to withstand hot climates and rough handling. The component being analyzed is dialed into the instrument on the mode switch. After the instrument is calibrated against a prepackaged standard solution, the sample cell is inserted (7). The light-tight cover is then slid over the sample compartment, uncovering the digital display and revealing the concentration reading for the selected component in the original blood sample (8). *Photographs courtesy of Denley Instruments Ltd.*

**The "Swizzlestick" was invented by Alan Renshaw, a member of the development team at the Clinical Research Centre.*

one thing, these colorimeters utilized absorbance filters to provide light of the selected colour (that absorbed by the reagent - substrate complex). In the dampness and stifling heat sometimes encountered in tropical countries, these filters are attacked by fungi and bacteria, and rapidly deteriorate. It was evident that an entirely new colorimeter design was needed if the stringent requirements for field use in developing countries were to be met.

From the start, it was clear that absorbance filters were to be avoided. It was necessary to have a light source producing only light of the desired colour. This was to be provided by a light-emitting diode (LED), a small semiconductor device (a p - n junction constructed so as to provide the maximum yield of light photons from electron-hole recombination). By then , light-emitting diodes had already become widely used in electronic displays and were very cheap, but were only available in two colours—red and green. The development team opted for the green LED, and hoped that chemical reagents could be selected or modified so that the reagent - solution complex absorbed this colour.

It was also evident that the colorimeter should have the capacity to analyze the content of haemoglobin in blood. Firstly, this test has a broad range of medical applications. A low haemoglobin level indicates an inadequate supply of red blood cells caused by bleeding, iron deficiency or disease of the bone marrow. Secondly, the test is relatively simple to perform. A sample of whole blood, including red and white blood cells, is added to the hemiglobincyanide reagent. This solution bursts the membrane of the red blood cells, frees the haemoglobin, and forms a cyanide - haemoglobin complex.

The initial red colour of the blood sample, due to bonding of some haemoglobin with oxygen, does not interfere with the analysis. The cyanide displaces oxygen from those haemoglobin molecules that are oxygenated and, of course, complexes those haemoglobin molecules that are not. The

Immunoassay tests in a portable laboratory kit allow rural health workers to diagnose disease

An important advance that allows clinical chemical tests to be performed in the most remote areas is the development of immunoassay tests. These utilize antibodies as highly specific reagents that selectively bind to certain proteins, nucleic acids, bacterial toxins or entire cells of microorganisms. The types of substances which can be detected has been greatly extended in the last decade, while the sensitivity of the tests and ease with which they are performed have been much improved. Simple, lightweight equipment and stable reagents have been developed, and these form the basis for a portable kit presently being evaluated for diagnosis of infectious diseases in tropical areas.

The kit provides clinical chemical back-up for health workers administering medical treatment and vaccinations to combat outbreaks of acute infectious diseases in villages located hundreds of kilometres from the nearest laboratory. The kit's ability to withstand rough handling was proven during five separate field trials, during which the kits were mailed from California to Cairo, carried on commercial airliners, and transported by small aircraft and Land Rover. In one mission, a light plane loaded with the diagnostic kit, a jet injector (for administering large numbers of immunization injections) and 5000 doses of vaccine was landed on rough airstrips in Upper Volta (East Africa). Using the immunoassay tests contained in the kit, medical personnel were able to confirm suspected cases of meningitis, identify the strain of meningococci bacteria responsible for the outbreak, and immunize village children (meningitis vaccines, which have been developed recently, are only effective against specific strains). When other bacterial infections were identified, specific antimicrobial therapy was recommended.

To test for a particular strain of meningococcal bacteria, the technique of counterimmunoelectrophoresis (CIE) is used. A small sample of cerebrospinal fluid (the fluid surrounding the spinal cord) is taken from the patient suspected of having meningitis, and is applied at one end of a strip of gel. At the opposite end of the gel strip is a small amount of a menigococcal antibody (which had been produced by an animal injected with a known strain of meningococcal bacteria). An electrical voltage, provided by a car battery, is applied across the gel strip, causing the bacterial agent and antibody to migrate towards each other. Where the two meet is determined by the relative mobility and electrical charge of their constituent proteins. If the antibody is specific against the particular microorganism or toxin, it crosslinks to the surface of the microbial agent and causes it to clump. Occurrence of the antibody - antigen reaction at the correct position on the gel strip provides a reliable confirmation of the presence of the suspected disease organism.

The same type of results are provided by a simple coagglutination test, in which the antibody reagent precipitates its respective microbial antigen. However, by combining the immunological reaction with electrophoresis, CIE offers greater specificity and sensitivity, providing positive confirmation only for those microbial agents which are precipitated by the antibody *and* have the correct mobility and charge.

Each technique, coagglutination and counterimmunoelectrophoresis, is best suited for certain ap-

haemoglobin - cyanide complex is intensely coloured and strongly absorbs green light emitted by the colorimeter's LEDs (with wavelengths of about 550 -600 nm). Pre-packaged vials of the hemiglobincyanide reagent were found to be stable for at least a year without refrigeration.

Since haemoglobin is contained in red blood cells, samples of whole blood are used for anlaysis. There is no need to separate blood cells from the clear solution of blood plasma in which they are suspended, as is required in other blood tests. Before these tests can be performed, the blood sample must be spun in a centrifuge or allowed to settle for a period of hours.

A suitable reagent was also found for the analysis of total protein concentration in blood plasma. The capability to perform this test was especially important for health workers in developing countries, since reduced levels of plasma proteins provides a reliable measure of malnutrition (or may indicate severe liver disease). Chemists at the Clinical Research Centre adapted the conventional Biuret reagent, which forms a copper complex with the peptide bonds of the protein. Here again, the blue-coloured complex absorbs the green LED emission.

Another common reagent, the dye bromocresol green, is utilized for the specific measurement of albumin, the main protein component in blood plasma. The deep colour of the reagent does not interfere with the analysis since this compound absorbs light outside the emission band of the light-emitting diode. However, when the dye binds to albumin, the resulting complex absorbs the beam of green light produced by the LED.

Each of these reagent - substrate systems generate a complex which absorbs green light and, in the colorimeter developed at the Clinical Research Centre, reduces the intensity of the LED light beam passing through the sample cell and reaching the semiconductor light detector. The electrical signal produced by the light detector is therefore related to the concentration of substrate in the sample, but the relationship between the two factors is logarithmic

plications. The capability to do both types of tests, points out Warren Sanborn in the *Appropriate Technology for Health Newsletter* (published in the *WHO Chronicle,* October 1980 and February 1981), extends the versatility of the portable kit to diagnose a wide range of bacterial, viral and parasitic diseases, as well as food poisoning caused by fungal toxins.

The portable laboratory kit contains a rugged microscope and selected stains, a compact incubator-waterbath, and equipment and reagents for performing coagglutination and counterimmunoassay tests. Its contents are protected from shock and heat by special insulation. Weighing only 13 kilograms, the case can be carried by one person and fits under the seat of a commercial airliner. *(Photograph by Warren Sanborn.)*

(following Beer's Law for the absorption of light by an absorbing compound in solution). An electronic circuit converts the output of the light detector to a value directly proportional to the concentration of the substrate being analyzed. An appropriate proportionality constant, determined by the complex's absorptivity of green light, is introduced when the colorimeter mode selector switch is dialed to indicate the test being performed. In each test mode, the sensitivity of the instrument may be adjusted by turning a calibration knob, bringing the concentration indicated on the display to coincide with the known concentration of a standard solution. The concentration of haemoglobin, total protein or albumin in the sample is then displayed directly on the digital readout of the colorimeter.

Field trials of the experimental colorimeter system were undertaken by staff from the Clinical Research Centre and by local medical officers in the West African nation of The Gambia. After a number of WHO-sponsored trials were completed, Denley Instrument Company (in Billingshurst, UK) undertook further development of the colorimeter system in preparation for commercial production.

The range of the system was extended to include three other important blood tests. A test for glucose (and other aldohexose sugars) was introduced for the diagnosis of diabetes. It utilizes ortho-toluidine reagent, which reacts with the aldehyde group of the sugar, forming a coloured condensation product.

The ability to measure the concentration of urea in blood plasma was also felt to be important, since elevated urea levels reveal chronic kidney disease or acute kidney failure. This test utilizes the very specific reaction of diacetyl monoxime with urea, which produces a group of coloured reaction products. The actual concentration of urea in the sample is obtained by comparing the value displayed by the colorimeter against a calibration curve obtained with a group of standard urea/benzoic acid solutions.

A sixth test procedure developed for the colorimeter determines the concentration of bilirubin in blood plasma. Excessive levels of bilirubin indicate a malfunction of the liver, and its concentration provides the doctor with a measure of its severity.

A production version of the instrument is now being introduced by Denley Instruments. It is powered by a standard 9 volt battery (the type used in many transistor radios) and uses two standard-size glass cells for the sample and blank solutions. All electronic circuitry is protected by encapsulation in silicone rubber. Chemical spills may be thoroughly cleaned by removing moulded rubber plugs which form the base of the two cell compartments. As well as manufacturing the colorimeter, Denley Instruments will offer prepackaged vials of reagents and standards, with complete kits for taking and processing blood samples (including swabs, sterile lances, glass capillaries, plastic putty and a tool for cutting the capillaries). The colorimeter and prepackaged kits are being evaluated by the World Health Organization in selected laboratories in Morocco, Algeria, Pakistan, Nepal, Burma and Papua New Guinea.

A radically different approach, using thin-film technology developed for the manufacture of photographic film, might soon allow simple clinical chemistry analyzers to be made at even lower cost and with greater versatility. These instruments would utilize conventional chemical reagents packaged inside compact, self-contained slides—each serving as a disposable reaction vessel and colorimeter cell. Such "miniature dry laboratories in plastic mounts no larger than postage stamps" have been developed by Kodak Research Laboratories for a range of clinical chemical tests. They are intended primarily for use with Kodak's newly-introduced Ektachem 400 analyzer. This is a very sophisticated, fully-automated microprocessor-controlled instrument designed to perform as many as 500 separate analyses per hour (more than *10 000 analyses per day* when in continuous use). Many of its fully automatic features (metering of samples and reference solutions onto slides; incubation of the slides and measurement of the developed colour; and storage, processing and print-out of the test results) are necessary only if a very large number of samples are to be analyzed. A very simple instrument would suffice if only a few samples were to be analyzed, and it is likely that Kodak will develop a relatively cheap, compact colorimeter for use with their colorimeter slides.

Kodak has developed colorimetric slides to measure most blood plasma components of clinical importance: total protein, albumin, glucose, urea and bilirubin - as well as uric acid, amylase and calcium. While Kodak has adapted conventional test reagents for some of their slides, new test reagents had to be devised for others.

For each analysis on a colorimetric slide, a fixed volume of blood plasma (10 microlitres) is applied to the slide's covering layer of porous material. Water and low-molecular-weight molecules (including the compound being analyzed) diffuse into an underlying layer of gelatin containing the test reagents (these may include enzymes, buffers, dyes and ion-exchange resins). The ensuing reaction generates a coloured product. The reaction is complete in about 5 minutes. The coloured product partially absorbs a beam of light as it passes through the reagent layer. The light beam, coming through the slide's underlying transparent support, is reflected by a reflective film above the reagent layer. It passes, once again, through the reagent layer before striking the light detector below. The reduction of light intensity caused by reflection from the slide is related directly to the concentration of the test compound in the plasma sample.

For the Kodak slide system to be useful in adverse field conditions, it would need to be integrated with a simple system for metering the desired 10μL volumes of sample and standard solutions. However, delivery of the exact droplet volume may not be essential, since the response of the instrument is relatively insensitive to variations in the volume of the sample. Larger droplets diffuse outwards to a larger area on the slide, rather than produce a higher concentration of the coloured complex. A 10% increase in droplet size will only cause a 1% change in the measured value of concentration.

Kodak has also developed a group of potentiometric slides to analyze concentrations of sodium, potassium, chloride and carbonate ions in blood

plasma. Monitoring of these ion concentrations provides an early warning that the patient is becoming severely dehydrated (as may occur in patients suffering from cholera and other diarrhoeal diseases) is accumulating too much fluid, or is developing a salt imbalance (which may occur after large amounts of fluids have been administered intravenously). These slides do *not* form a coloured complex. Rather, they generate a small voltage when droplets of blood serum and standard solution are applied to the slide's two thin-film multilayer electrodes. The voltage is proportional to the ratio of salt concentrations in the sample and reference solution, and can readily be measured with an electrometer.

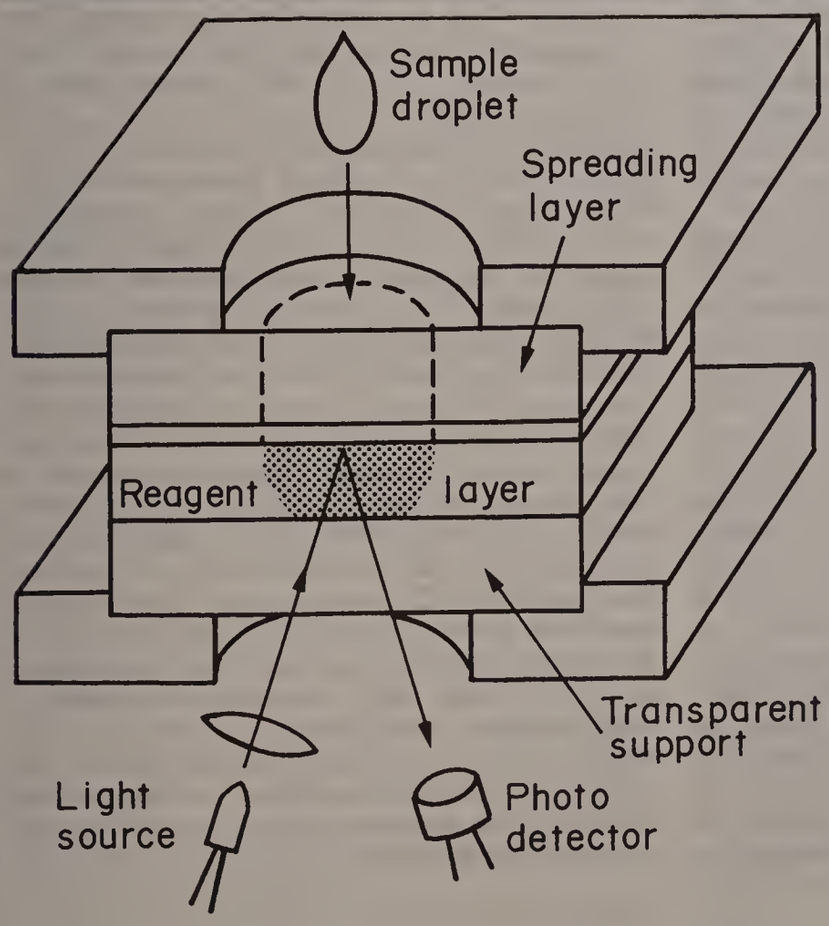
The potentiometric slide for measuring chloride ion concentrations, for example, makes use of two Ag/AgCl electrodes. Each electrode consists of a film of silver metal about 0.5 microns thick (formed by evaporation of silver metal onto a polyester film base) which is partially converted to silver chloride by immersion in a chlorochromate oxidizing bath. A thin covering of cellulose acetate allows chloride ions to diffuse to the Ag/AgCl electrode, but blocks the passage of other ions which might interfere with the analysis.

A droplet of blood plasma is applied to the sample electrode. To the reference electrode is applied a droplet of standard solution of known concentration. The chloride ions in the two solutions affect the equilibrium at their respective electrodes:

$$AgCl + e \longrightarrow Ag + Cl^-$$

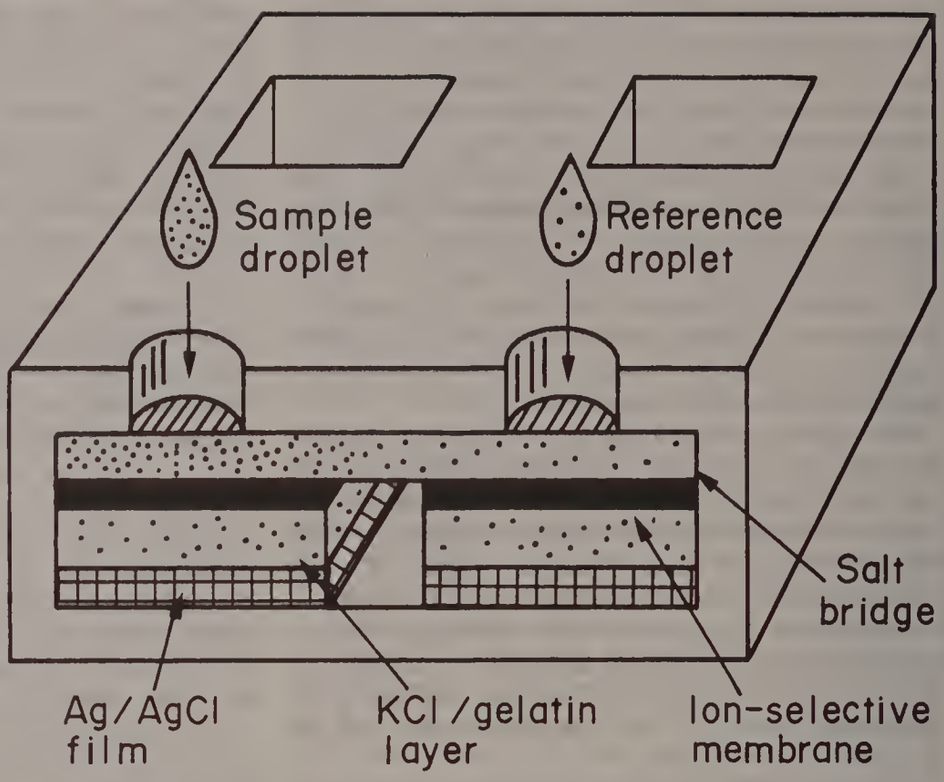
Because the sample and reference electrodes are identical, their potentials *would* exactly cancel—*if* the chloride ion concentration were the same in the two solutions. When the chloride ion concentrations are different, as they will be in nearly every case, the slide will act as a concentration cell and generate a net voltage. The voltage depends upon the ratio of chloride ion concentrations in the sample and reference solutions. A ten-fold difference in concentration, for example, will give rise to a 30 millivolt potential.

The slide for measuring potassium ion concentrations utilizes the same Ag/AgCl electrodes but, in this case, the potential developed by each electrode remains constant. A fixed concentration of chloride and potassium ions is maintained at the electrode surface by a layer of gelatin containing KCl. On top of this layer is an ion-selective membrane. Consisting primarily of polyvinyl chloride and plasticizers, the membrane acts as a hydrophobic fluid medium blocking the passage of all ions except potassium. A selective binding agent for potassium, valinomycin, is dissolved in the membrane. This carrier molecule can bind potassium ions in the solution on one side of the membrane, diffuse through the membrane, and release the potassium ions into the solution on the other side of the membrane (where the potassium ion concentration is lower). However, it is not the passage of potassium ions through the membrane that is important, but the electrical potential which it generates. Negative ions cannot pass through the membrane to balance the electrical charge carried by potassium ions. The initial migration of potassium ions (driven by the difference in potassium ion concentration on opposite sides of the membrane) gives



Colorimetric slides act as miniature disposable reaction vessels and sample cells for analyzing a variety of compounds in blood plasma. The actual structure of the slide may vary depending upon the particular compounds to be analyzed, but all slides have the same general features. When a droplet of blood plasma is applied to the slide, the solution rapidly diffuses into the top "spreading layer". It spreads outwards until the capillary pores are saturated, thereby ensuring that the coverage of sample fluid per unit area is nearly independent of the volume of the applied drop. The solution then diffuses through a reflective film and into a reagent layer, leaving large protein molecules and blood cells behind. In the reagent layer, the sample fluid initiates a series of reactions leading to the formation of a coloured complex.

The concentration of the complex is measured by its absorption of a light beam passing upwards through the reagent layer and then reflected downwards by the reflective film. The actual scale of the thin-film layers is tiny: all chemical processes occur within an area of 1 cm^2 and a thickness of 0.1 mm.



Potentiometric slides utilize the different ion concentrations in a sample and standard solution to generate an electrical voltage. Droplets of blood sample and standard solution are applied to their respective drop holes, as shown in this simplified cutaway view of a slide for analyzing potassium. The two solutions are drawn by capillary action into a salt bridge of porous paper. This layer forms a continuous electrically-conducting path and ensures that both solutions have the same electrical potential. Each permeates to an ion-selective membrane, across which an electrical potential arises from the difference in potassium ion concentration across the membrane. On the opposite side of the membrane, a KCl/gelatin layer maintains a constant concentration of K^+ ions. The net voltage generated between the two electrodes depends only on the K^+ concentrations of the sample and reference solution.

rise to an electrical potential which opposes further diffusion of potassium ions. The membrane potential soon reaches a value at which it exactly counterbalances the effect of the potassium concentration gradient across the membrane. As before, the membrane potentials at the sample and reference electrode would counterbalance each other—if the potassium concentrations in the sample and reference solution were the same. Different potassium ion concentrations give rise to a net cell voltage.

Kodak's colorimetric and potentiometric slides are the most advanced clinical chemistry slide systems, but it is not surprising that other manufacturers of photographic films should apply their expertise in thin-film technology towards developing slide systems for chemical analysis. Late last year, Fuji Photo Film Company (located in Tokyo, Japan) introduced a colorimetric slide system for measuring glucose levels in blood. Structurally, their slide is very similar to that made by Kodak: it contains a porous spreading layer, reflecting film, reagent layer and transparent support held in a plastic mount. Fuji points out that their slide system offers a major advantage over conventional methods for measuring glucose in blood. The slide's spreading layer filters blood cells from the sample, so that only the plasma diffuses into the lower layers. Because red blood cells do not permeate below the reflection layer, they are not in the light beam when an absorbance measurement is made. Thus, there is no need to sediment blood cells by spinning the blood sample in a centrifuge. This simplifies the procedure and the equipment requirements for blood glucose analysis.

So far, Fuji has only developed a slide for measurement of glucose, but researchers at Fuji and the University of Tokyo Hospital are presently developing slides for the analysis of urea, amylase, bilirubin and are considering potentiometric slides for the measurement of blood plasma electrolytes.

One important area which remains to be explored is the stability of clinical analysis slides in tropical conditions. Reagents for the clinical analysis slides are contained within a layer of gelatin—the same protein-water gel which is used as a matrix for light-absorbing dyes in absorbance filters (and also used to contain light-sensitive silver salts in all photographic film). Whether this gelatin/reagent layer will resist decomposition in tropical climates has yet to be demonstrated. However, clinical analysis slides (unlike absorbance filters) can be kept in sealed packages until ready for use, and thereby protected from humidity and bacterial attack. Fuji has noted that their glucose slides, which are sealed in an aluminium foil packet, are stable for at least one year at 4°C. They are now conducting experiments to determine their useful lifetime when stored at room temperature or in tropical conditions. These studies should soon resolve this question and open the way for widespread adoption of slide systems for simple, low-cost clinical chemistry analysis.

The management of research projects

The word "management" conjures up different impressions to different people. At one extreme is the young chemist who wants to be a chemist, not a manager. At the other end of the spectrum is the young graduate, hell-bent on promotion to "be a manager". The truth of course is that neither of these people recognise what management really is—the organisation of resources to achieve an objective.

If one accepts this definition of management, then even a chemist working in complete isolation, if there is such a person, is a manager. His most important resource would then likely be himself.

The most prevalent view of management however is that which occurs when a chemist is promoted, or otherwise formally "put in charge" of other people. But there is a more important form of management which may be thrust on the young chemist very early on, in his or her first job. This is known as *project management*.

by Professor John Mann,
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The majority of chemists, soon after graduation, will find themselves working in a "project team". Management of part of that overall project will almost inevitably soon follow. In this respect, management responsibility comes to the chemist much sooner than he or she might have expected. Certainly, this management responsibility will come sooner than formal managership of a department in an organization.

The importance of good management of even a small part of an overall project cannot be emphasized too strongly. Any organisation, whether it be an industrial concern, a commercial undertaking, a Public Service or one of the Armed Services, ultimately depends for its reputation on the quality, cost and timeliness of its project work. This is certainly true of research laboratories, which arrange virtually all their work into projects. Other organisations may only occasionally organise their work into projects, but nonetheless, rely heavily on the success of these few projects (or "special assignments" as they are frequently called). The reputation of the chemist managing the project or sub-project will rise or fall with its success or failure.

It should not be thought that success in managing a small sub-project will necessarily come easily. Indeed, project management is usually far more difficult than management of a section in the organisation. The reason for this paradox is that many projects are undertaken outside the normal organisational structure. The project manager is usually responsible to a different individual or group than his usual Section Head. He may also be required to use resources (the glassblower or machine shop, electronic technicians, or facilities at other institutions) which are already committed to ongoing work within the normal organisational operation. In these circumstances the project manager must rely on goodwill and persuasion. Authority to undertake this work must be obtained from the executive to whom he is reporting, rather than be derived from his own seniority within the organisation.

A young chemist may therefore have an important need of "management skills" early in his or her career. Opinions vary about whether this training should be given to undergraduate students, or later in their careers when it is imminently needed. Chemists are probably most receptive to such training, and have greatest need, after graduation.

This is particularly true for management training involving "human behaviour" or "interpersonal skills". For example:

— The chemist will become concerned with the leadership and motivation of others, sometimes more senior than himself and frequently in disciplines other than chemistry, who are contributing to "his" project.

— He will become involved in specifying characteristics of "his" future project team.

— He will become involved in recruiting "his"

team, from either within the organisation, or from elsewhere.

— He may need to conduct or chair meetings.

— The project manager will also have to make verbal presentations on behalf of the team, to colleagues, senior management, and possibly directors.

— He may need to nurture innovation and creativity in the project team.

In addition to these interpersonal skills are managerial skills requiring numerical analysis. In planning a project, the chemist will need to consider the order in which tasks have to be done, the possibility of pursuing parallel paths simultaneously, and the dependence of those parallel paths on each other. Using formalised network methods, the project manager can infer the sequence by which various parts of the project should be undertaken to complete it in the shortest time, and might reveal where additional resources are most critically needed.

While the calculation of project profitability is often left to other people, most project managers want to reassure themselves of the financial viability of a project, even before assuming responsibility for it. No chemist wants to devote his efforts to a financially "doomed" project. Many projects which have been successful in a technical sense failed to achieve their objectives simply because the return (cash from sales or royalties, or acknowledgement of results) commenced too late after the initial expenditures of money and effort.

No matter how profitable or worthwhile a project might ultimately be, there is no point in starting or continuing it, if it involves so much expenditure that the organisation would not be able to withstand the drain on its resources before the project started providing a return. Even a project manager in a university research team has to make sure that his work-plan will not require an excessive investment of resources before results are published, since publication of papers may well be an implied prior condition for continued funding of the project. The ability to read and analyze a balance sheet is a basic skill in many commercial organisations, but even in non-commercial organisations, an appreciation of accountancy procedures is highly desirable.

In the case of a Research & Development project, expenditure is often measured solely by the scientific and technical effort which has gone into the project. Monitoring this expenditure and the achievement of technical "milestones" at suitable intervals are essential for effective project control. In non-R & D projects additional measures of progress may be required, such as the number of orders placed or the number of process units commissioned. The project manager must decide what information is necessary to monitor resource utilisation and achievement, and at what intervals this need be monitored.

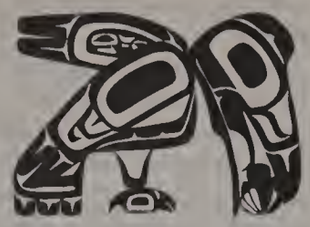
Numerical methods may also be applied to project management in decision-making. Mathematical procedures have been developed which enable the project manager to compare the alternative outcomes of a decision, or a sequence of decisions, taking into account the probability of success at each stage. Such numerical methods provide useful guidance, but are not a substitute for in-depth study or thought.

Mention should also be made of the legal armoury with which project managers must be equipped. Industrial project managers may have greatest need of Contract Law, whereas his R & D counterpart may need familarity with Patent Law. Both will require a knowledge of Employment Law as well as Health and Safety Legislation.

The chemically-trained project manager may feel somewhat overwhelmed by all these requirements. There are, however, a number of courses available which attempt to help the chemical manager cope with these demands. These courses are advertised in professional journals, and brochures are sent to training officers in most organisations. Some companies encourage their staff to take such courses, but more often it is left to the initiative of the individual chemist to identify his or her own training requirements.

The chemist who has not had to sit through formal lectures for a number of years may doubt his ability to maintain concentration in a formal lecture situation. This is only to be expected, and project management short courses should take this into account. All courses for mature people rely heavily on case-study and syndicate group work. A substantial degree of participation during class-work is also normal, and indeed beneficial for all class-members.

A record of successful project management is something of which the chemist may feel justifiably proud. The aim, of course, is to have successfully completed as many projects as possible, but the greatest reward comes from the inner satisfaction of having made the right decisions at the right times—of having *managed* each project well.



Technical breakthrough opens way for cheap solar cells & new photocatalysts, keynote speaker reports at IUPAC Congress

The potential for sunlight to provide most of man's energy needs is widely recognized. The major obstacle has been the lack of a cheap and efficient way to convert sunlight to a more concentrated form of fuel or electrical energy.

The conventional approach, now receiving renewed attention, is the cultivation of photosynthetic plants with a high yield of cellulose, fermentable carbohydrates or vegetable oils. Such crops have been utilized for tens of thousands of years, but few countries have arable land which could be devoted to additional biomass production. Furthermore, the energy yield of a biomass crop constitutes only about 1% of the total incident solar radiation during the period of plant growth. Of this energy yield, a significant part would need—quite literally—to be "plowed back" in the form of fertilizer, pesticides and mechanical working of the soil.

A much newer technique offers a radically different approach; producing chemicals or electricity directly from sunlight with semiconductor cells. Direct conversion of sunlight has only been practical since the early 1950's, when the first efficient semiconductor solar cells were made. Their striking advantages were immediately apparent—these devices provided power whenever they were illuminated with sunlight, were extremely reliable, and converted a large fraction of the incident sunlight into electricity. By 1958, when semiconductor solar cells were used in the first US space satellite (powering its electronic instruments for eight years), solar-electric conversion efficiencies of 10% had been achieved. The unusual capabilities of solar cells were demonstrated very recently when an experimental airplane, powered solely by solar panels covering its wing area, successfully flew across the English Channel from France to England.

In spite of higher operating efficiencies and modest cost reductions achieved by improved manufacturing techniques, semiconductor solar cells are still restricted to specialized applications by their high cost. For solar power generation and photochemical production to be practical on a massive scale requires a dramatic breakthrough in technology—one that would allow a new generation of solar cells to be made by simple chemical means from polycrystalline thin films. The scientific foundation for such a breakthrough is now in place, according to Dr. Adam Heller. (Head of the Electronic Materials Application Research Department at Bell Laboratories in Murry Hill, New Jersey, USA.) Speaking at the IUPAC Congress in Vancouver*, he explained the underlying principles of operation of solar-electric and solar-chemical cells, the hitherto unsolved problems barring the use of polycrystalline thin films, and how these technological problems have now been breached.

* *Dr. Heller's keynote lecture, entitled "Electrochemical solar cells", will be among those included in the proceedings volume of the IUPAC Congress, to be published in early 1982 by Pergamon Press.*

Present-day solar cells are generally made from single crystals of pure semiconductor, or polycrystalline materials with large crystal grains. Common materials are GaAs, InP and silicon. The atoms are chemically bound into the crystal structure by overlap of their atomic orbitals. This overlap reforms the atomic orbitals into a series of low-energy molecular orbitals (merging to form a "valence band") which are normally occupied by electrons, and a group of high-energy antibonding orbitals which are normally unoccupied.

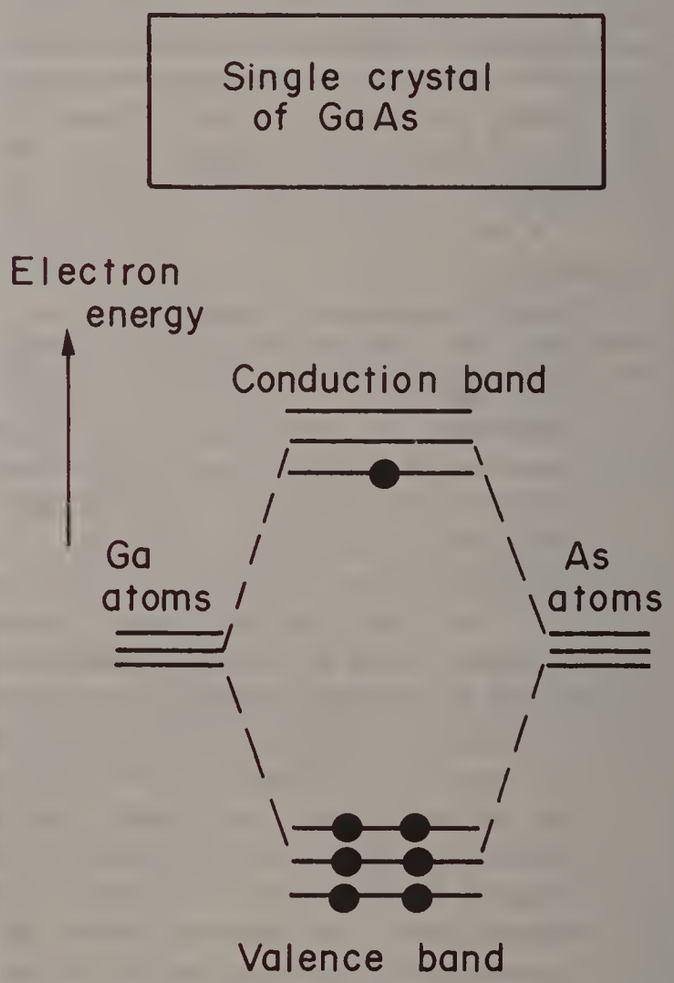
In a crystal of pure semiconductor, the constituent atoms provide just enough electrons to fill all the low-energy valence band orbitals. However, by intentionally adding small amounts of certain impurity atoms (for example, by adding phosphorus to silicon), one can increase the number of valence electrons beyond the number that can be accomodated in the valence band. Excess electrons must go into the high-energy antibonding orbitals comprising the "conduction band", in which the electrons are free to migrate through the crystal. Such mobile electrons account for the electrical conductivity of n-type semiconductors (possessing *n*egative charge carriers).

To make a conventional solar cell, atoms of "p-type" dopant are allowed to diffuse into the surface of the n-type semiconductor. These dopant atoms can "fit" into the crystal structure of the underlying semiconductor, displacing a few from their sites in the crystal. P-type dopant atoms have fewer valence electrons than the atoms they replace. Consequently, in the doped region, there are no longer enough electrons to completely fill the valence band. A few bonding orbitals then have a shortage of one electron or, in other words, a "hole". Holes behave as positive charge carriers. An electron vacancy, which is initially located on one localized bonding orbital, can migrate through the p-type layer as electrons move from filled bonding orbitals on adjacent atoms. In this way, valence-band holes conduct an electric current through a p-type semiconductor in exactly the same way (but in the opposite direction) as do electrons in the conduction band of an n-type semiconductor.

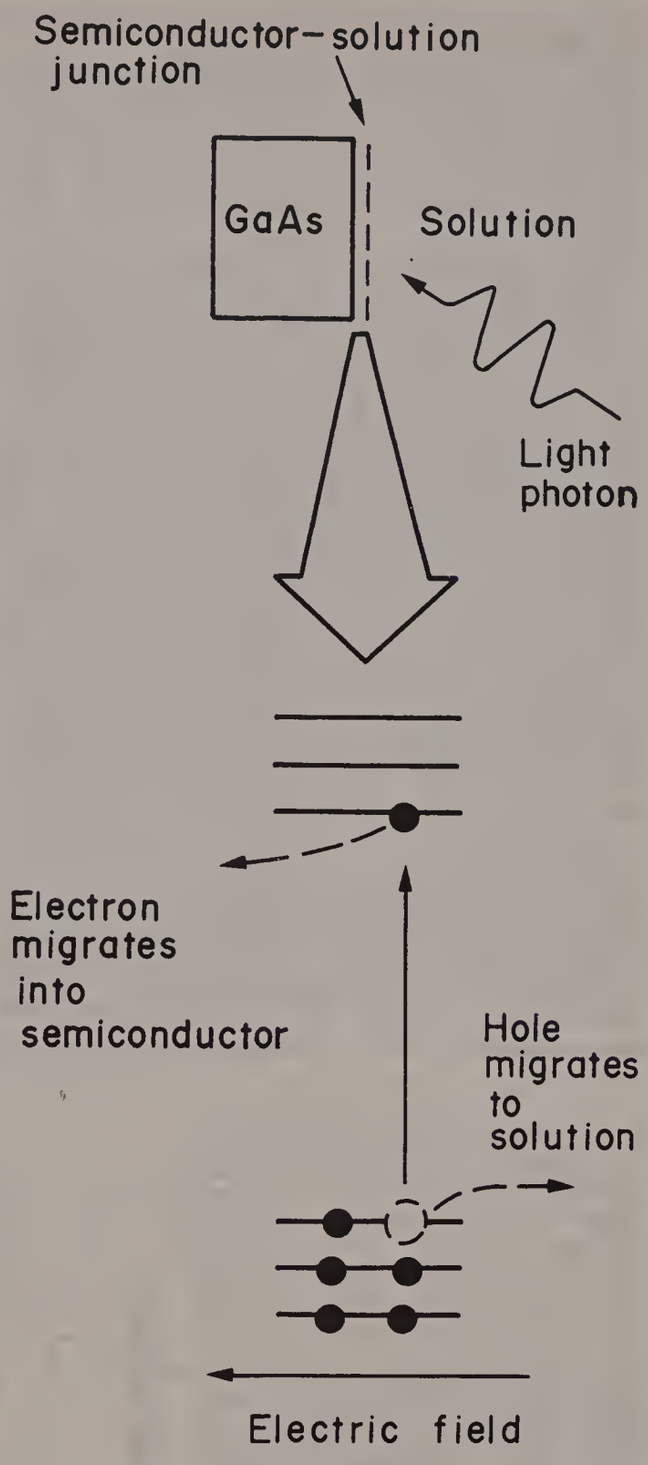
The critical part of a solar cell is not the n-type or p-type semiconductor layers, but the p - n *junction*. On one side of the junction is a surplus of electrons in antibonding orbitals (which create a strongly reducing environment). On the other side is a deficiency of electrons in the bonding orbitals of the crystal (which create an oxidizing environment). When a p - n junction is initially formed, electrons migrate from the n-type semiconductor to the p-type semiconductor, thereby equalizing the chemical potential of electrons throughout the crystal and—of crucial importance—creating an electric field across the p - n junction.

When the p - n junction is illuminated, an incident light photon may impart its energy to an electron in a bonding orbital (in the valence band), exciting it to an antibonding orbital (in the conduction band). This is exactly analogous to the absorption of visible or ultraviolet light by a molecule. For the excitation energy to be utilized, the excited electron must do chemical or electrical work before it can dissipate its energy and return to the valence band. The electric field in the p - n junction prevents electron-hole recombination by pulling the electron into the n-type semiconductor, and pushing the hole into the p-type material. Movement of free electrons into the n-type semiconductor creates a reducing environment in this region, while the p-type layer becomes oxidizing. In fact, oxidation and reduction reactions can be carried

A semiconductor, such as gallium arsenide, is bound into a well-ordered crystalline structure by overlap of atomic orbitals on the constituent atoms. This overlap gives rise to a series of localized bonding orbitals (which essentially form a continuum of energy states, collectively termed the "valence band") and a series of antibonding orbitals which extend throughout the crystal (termed the "conduction band", because electrons in these orbitals can migrate through the crystal). Nearly all electrons in the material are confined within the valence band, since these orbitals are states of low energy. However, if the valence band is completely full, any additional electrons (from impurity "dopant" atoms) must enter the high-energy conduction band (as shown here for tin-doped gallium arsenide). We then have an n-type semiconductor.



If the semiconductor has slightly fewer electrons than are needed to fill the valence band, we then have a p-type semiconductor. The remaining electron vacancies in the valence band can receive electrons from orbitals on adjacent atoms. When an electric field is applied, the valence band "holes" can migrate through the crystal (in the opposite direction as would electrons).



When a semiconductor-solution junction is illuminated with light, an electron can be excited from the bonding to antibonding states, leaving a "hole" in the valence band and depositing an electron in the conduction band. Recombination of the electron-hole pair is prevented by an electric field at the surface of the GaAs semiconductor, which extracts the hole into the solution and causes the electron to migrate into the bulk semiconductor.

In order to utilize as much of the incident solar radiation as possible, one should choose a semiconductor whose bandgap (the energy difference between the valence and conduction band) is well matched to the range of photon energies in sunlight. Semiconductors with a large bandgap can generate a high chemical (or electrical) potential, but only absorb the high-energy ultraviolet component of solar radiation. Semiconductors with a small bandgap also absorb photons in the visible and near infrared range of the solar spectrum, but generate a small potential (and are also subject to electron-hole recombination). A bandgap of about 1.4 eV is optimal, converting the maximum amount of incident solar energy (28%) into chemical potential.

out by immersing an irradiated p - n junction into a electrolyte solution. More commonly, electrons leave the n-type layer and pass through an electrical device (the "load") before recombining with holes in the p-type layer.

So why do we need a perfect single crystal to make a p - n junction solar cell? After all, as Dr. Heller argues, polycrystalline materials are far easier and cheaper to fabricate. One main obstacle until now, he points out, has been the diffusion of dopant atoms between the crystal grains, which occurs about 10 000 times faster than diffusion into the surface of a crystal. This causes randomly-oriented p - n junctions to form throughout the semiconductor material, thereby preventing the efficient collection of electrons and holes. Where p and n regions are both in contact with a metal electrode, electrons can flow directly from one region to the other through this "shunt path", bypassing the external circuit. The most fundamental problem, however, is that photogenerated electrons and holes rapidly recombine at boundaries of crystal grains.

In order to investigate the limitations of polycrystalline semiconductors and ultimately to overcome them, Dr. Heller experimented with liquid-junction solar cells. In these cells, a junction is created when a semiconductor is immersed into an electrolyte solution. An electric field appears spontaneously at the semiconductor-solution interface, arising from different chemical potentials of the n-type semiconductor and the oxidizing solution (or, alternatively, from different chemical potentials of a p-type semiconductor and a reducing solution). Since doping is not required to form the junction, the problems of randomly-oriented junctions and shunt paths are avoided. Thus, making an efficient solar cell depended only on solving the problem of electron-hole recombination at crystal grain boundaries—and that Dr. Heller has now achieved.

The research group at Bell Laboratories initially studied liquid-junction solar cells in which an n-type semiconductor served as a photoanode. In these

cells, holes produced by illumination of the semiconductor surface are attracted towards the solution interface, where they oxidize electrolyte ions. Simultaneously, electrons migrate into the bulk of the semiconductor, pass through the load, and reduce electrolyte solution at an inert counter-electrode.

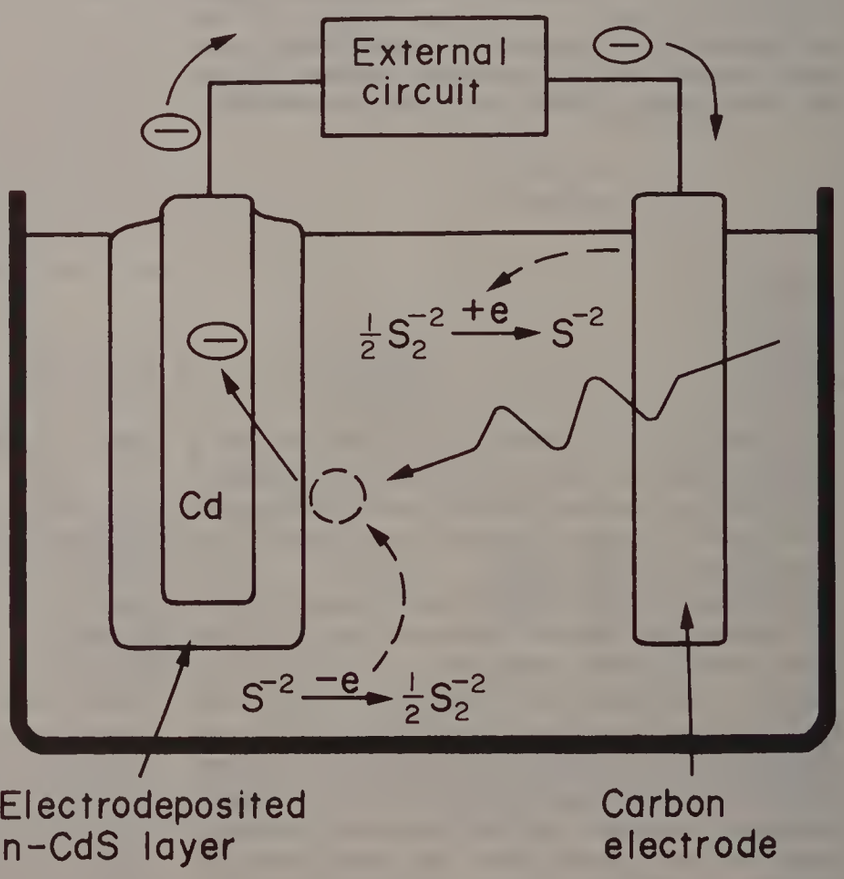
In 1976, Drs. Heller and Miller prepared the simplest solar cell ever constructed, a liquid-junction CdS cell. The same cell is now used to demonstrate photochemical principles in some general chemistry courses. To form the cell, a cadmium strip is placed into S^{-2}/S_2^{-2} solution with a carbon counter-electrode. A layer of CdS semiconductor is deposited on the cadmium strip by applying an electrical voltage across the two electrodes. Subsequent illumination of the CdS photoanode generates electron-hole pairs near the surface of the semiconductor. Electrons flow through the external circuit and then into the carbon electrode. There, they reduce the S^{-2}/S_2^{-2} solution. Simultaneously, holes oxidize the solution at the photoanode. Such cells are regenerative—that is, illumination of the photoanode causes no net chemical change. The entire energy of the absorbed light can be converted to electrical power.

Liquid-junction solar cells can also utilize light energy to cause a chemical reaction (or to reduce the electrical voltage needed to bring about an electrolysis reaction). In 1976, a Russian research group developed a cell which could electrolyze water to hydrogen and oxygen. The electrolysis reaction occurs on particles of n-type TiO_2 semiconductor that had been partially coated with platinum. The TiO_2 surface functions as a photoanode, oxidizing water to oxygen. Electrons migrate through the TiO_2 semiconductor to the platinum, and reduce protons to hydrogen gas. Because the TiO_2 semiconductor absorbs only ultraviolet radiation, of which there are relatively few photons in sunlight, the efficiency of this process is quite low. Recently, however, Dr. Heller developed the first photocathode (composed of InP with noble metal islands) which can efficiently reduce protons to hydrogen gas utilizing visible and near-infrared light, as well as ultraviolet radiation.

These efforts are leading to photochemical cells for a variety of reactions. One notable development (reported in *Chemical & Engineering News,* July 27, pp. 40 - 42) is a photocatalyst that—when exposed to visible light from a lamp or sunlight—dissociates hydrogen sulfide to hydrogen gas and sulfur. This process could have commercial importance as a method to remove H_2S from "sour" natural gas. The catalyst consists of colloidal cadmium sulfide particles in an aqueous solution. A small amount of ruthenium oxide is incorporated into the CdS particles in order to accelerate the transfer of holes from the semiconductor to the solution. Absorption of visible light promotes electrons to the semiconductor conduction band, providing the chemical potential required to reduce water to hydrogen gas and

A very simple liquid-junction solar cell is made by electrodepositing a CdS semiconductor layer on a cadmium strip. Absorption of light causes electrons to be ejected from valence band orbitals at the semiconductor-solution junction. The electric field at the junction pulls electrons into the cadmium strip, from which they are free to travel through the external circuit and into the carbon counter-electrode, where they reduce disulfide ions (S_2^{-2}) in the solution. Holes left behind at the CdS photoanode surface are strongly electron-withdrawing and oxidize the S^{-2} ions in solution.

The oxidation reaction at the photoanode is the reverse of the reduction reaction at the carbon counter-electrode. No net cell reaction occurs, so the entire energy imparted during the initial formation of the electron-hole pair can be expended by the electrons in the external circuit.



Such liquid-junction solar cells, in which the semiconductor is a photoanode, deteriorate after exposure to high light intensities. The oxidizing environment created by hole formation at the semiconductor surface eventually corrodes the semiconductor. Within the last few years, however, researchers have succeeded in making liquid-junction solar cells in which the semiconductor is a photocathode. In these cells, illumination of the semiconductor creates a reducing environment at its surface and, in this way, actually extends the lifetime of the cell.

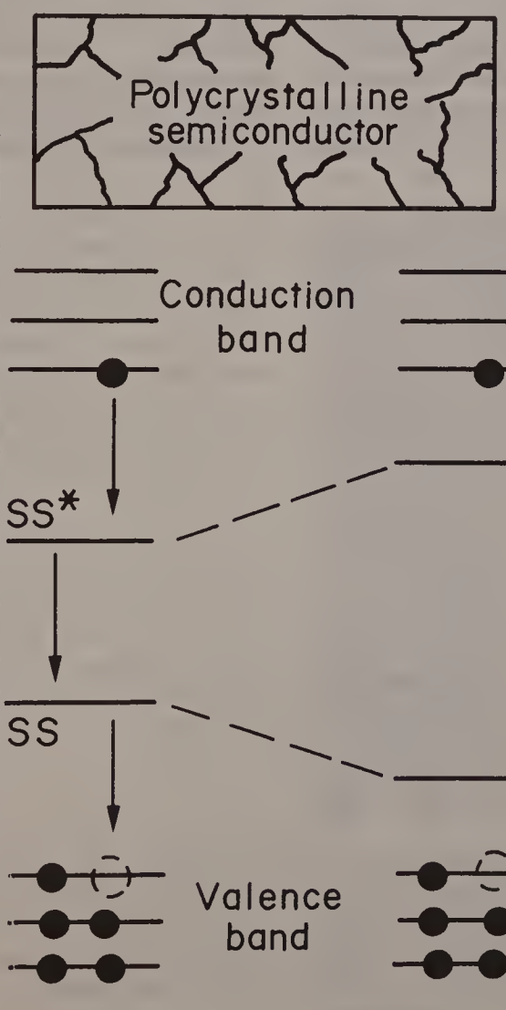
hydroxide ions. The OH^- ions reform water by stripping hydrogen from H_2S, leaving S^{-2} ions. Sulfide ions are then oxidized to elemental sulfur. The developers of the $CdS\text{-}RuO_2$ photocatalyst report that hydrogen/sulfur production occurs very rapidly and utilizes most of the incident light photons.

The amount of incident light which is absorbed by a semiconductor—and which can then be converted to electricity or chemical energy—depends upon the semiconductor bandgap, the energy difference between its conduction band (anti-bonding orbitals) and valence band (bonding orbitals). Cadmium sulfide has a fairly large band gap (2.4 electron Volts), so that only light in the blue end of the solar spectrum has enough energy to excite an electron to the conduction band, and create an electron-hole pair. Red or green light, with a lower photon energy, are not absorbed by CdS. Semiconductors with a larger bandgap, like TiO_2 (with a 3 eV bandgap), absorb only violet and ultraviolet light. This radiation comprises an even smaller fraction of the total energy in sunlight, but can be utilized to generate a high oxidation - reduction potential or electrical voltage.

The trade-off between the fraction of the light spectrum that a semiconductor can absorb, and the potential that it can generate, proscribe a ceiling on the maximum efficiency with which a semiconductor junction can convert radiation to chemical or electrical potential. This limitation does not reflect an inherent weakness of the semiconductor junction, but rather, is a consequence of using a radiation source like sunlight, which contains such a wide range of photon energies. We cannot afford to dismiss sunlight as an energy source simply because it has a broad spectral distribution; it is, by far, the cheapest and most widely available radiation. We must learn to use as much of the solar energy spectrum as we can. To do so, we should select a semiconductor with a bandgap of about 1.4 eV. With this optimal bandgap, a semiconductor junction could (in theory) convert 28% of the total incident light energy to electricity or chemical potential. By comparison, manufactured silicon solar cells presently operate at about 12% efficiency, and experimental cells have approached 20% efficiency.

The theoretical efficiency limit was hardly approached by liquid-junction solar cells made from polycrystalline semiconductors with a bandgap below 2 eV. Electron-hole recombination severely reduced their power output. For example, Bi_2S_3 has a bandgap very close to the optimal value of 1.4 eV, and Bi_2S_3 photocells should be able to utilize sunlight more efficiently than CdS cells. In actual fact, polycrystalline Bi_2S_3 solar cells produce *100 times less* current than cadmium sulfide cells. It appeared that the high rate of electron-hole recombination at grain boundaries would render such cells useless—or so it seemed until a few years ago.

At that time, Dr. Heller began to explore why electron-hole recombination occurs at grain boundaries. What was different about the chemical bonding at grain boundaries, he wanted to know, from the bonding in single perfect crystals? The answer, it turned out, is that some atoms at a grain boundary form weak chemical bonds to neighbouring atoms. Overlap of their atomic orbitals is marginal, and



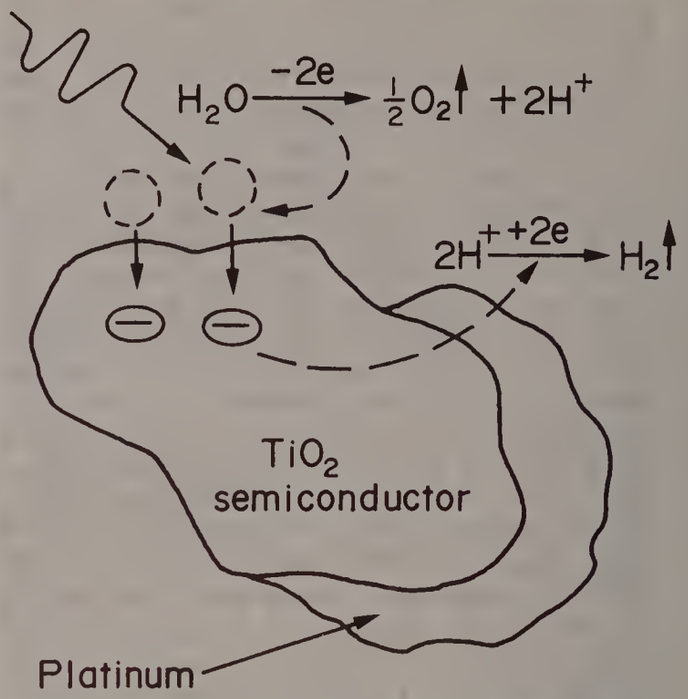
Polycrystalline semiconductors contain weakly-bound atoms at the edge of crystal grains, giving rise to energy levels which are only slightly bonding or antibonding (shown here as SS and SS*). These levels are intermediate in energy between the valence and conduction bands, providing a set of "stepping stones" for an excited electron to rapidly hop down to the valence band. In taking a series of small downward steps, the electron can transfer its energy to the vibrational energy levels of the semiconductor crystal. This rapid electron-hole recombination has previously prevented the use of inexpensive polycrystalline semiconductor materials in photoelectric and photochemical cells.

Recent experiments at Bell Laboratories (USA) have shown that electron-hole recombination in polycrystalline semiconductors can be greatly reduced by allowing certain impurities to diffuse into the crystal grain boundaries. These impurities form strong bonds to loosely-bound atoms at the edges of crystal grains. This bonding increases the energy separation between the bonding and antibonding states of these atoms, restoring a sufficiently wide energy gap to prevent excited electrons from dissipating their energy as heat.

gives rise to bonding and antibonding orbitals intermediate in energy between the valence and conduction bands. These intermediate energy levels act as a series of steps for excited electrons to hop from the conduction band down to the valence band. The energy gained by an electron in undergoing each stepwise transition is small enough (a fraction of an electron Volt) to be dissipated as vibrational energy in the crystal lattice. In this way, the initial excitation energy is rapidly degraded to heat.

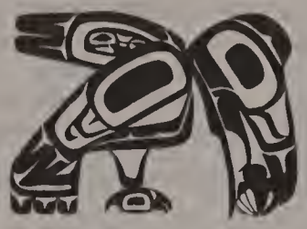
What is needed to prevent electron-hole recombination in polycrystalline semiconductors, Dr. Heller concluded, is to strengthen the bonding of atoms at grain boundaries. Rapid diffusion of ions along grain boundaries, which had previously been considered a major obstacle to using polycrystalline semiconductors, provided easy access for chemical modification of grain boundaries. Dr. Heller was able to strengthen the bonding of weakly-bound atoms at grain boundaries, by simply dipping the semiconductor into a solution of impurity ions which are strongly chemisorbed. The impurity need only permeate several thousand atomic diameters below the semiconductor surface, a depth within which nearly all incident light is absorbed by GaAs or InP. Immersion of a polycrystalline semiconductor film into a solution of the chemisorbed impurity for about one minute is often sufficient to reduce electron-hole recombinations to a small fraction of its former value. In the case of liquid-junction solar cells made from polycrystalline GaAs, chemisorption of Ru^{+3} at grain boundaries caused a fourfold increase in efficiency. A more dramatic effect is achieved by chemisorption of silver ions on grain boundaries of polycrystalline indium phosphide. The efficiency of the resulting liquid-junction InP solar cells increased as much as 500 times, with maximum improvement achieved in InP films with the smallest crystal grains.

Solving the problem of electron-hole recombination at grain boundaries has effectively opened the way for liquid-junction solar cells of reasonably high efficiency to be made from cheap materials using relatively simple technology. Following this breakthrough, we can anticipate the development of advanced, low-cost solar-chemical cells, photocatalysts and new types of solid-state solar-electric cells made from cheap polycrystalline semiconductor materials.



Chemical potential generated when an electron-hole pair is formed can be utilized to bring about a chemical reaction, such as the solar electrolysis of water. This reaction has been carried out (although at low efficiency) using colloidal particles of TiO_2 semiconductor which have been partially coated with platinum. The TiO_2 serves as a photoanode, at which holes oxidize water to oxygen gas and hydrogen ions. Electrons migrate to the platinum coating, where H^+ ions are reduced to hydrogen gas.

Impressions of the IUPAC Congress



Those attending a chemistry conference are often struck initially by the contrasting views and divergent opinions. After several days at the conference, however, one usually plunges below the turbulent superficial layer of foam and spray, and discovers that the main flow of developments is advancing in a remarkably consistent direction.

So it was at the IUPAC Congress. Here, of course, a single main thrust of recent advances was not immediately apparent, since more than two dozen subject areas were discussed—often simultaneously in different lecture rooms and poster sessions. A few lectures did stand out for their extraordinary importance and interest, and these will be discussed in detail in feature articles appearing in this and future issues of *Chemistry International*. Here, the *Chemistry International* reporter and Editor presents his views of the IUPAC Congress; some of those ideas and images which continued to swirl through his mind well after leaving behind the Pacific coast of Canada.

The evolution of life

Those participants at the IUPAC Congress who expected the opening ceremony to be a long series of dull speeches were in for a shock. The opening lecturer, Nobel Laureate Manfred Eigen (of the Max Planck Institute for Biophysical Chemistry in the Federal Republic of Germany) plunged into the technical progamme much earlier and far deeper than anyone had anticipated. He probed the very meaning of life: a property that no one has yet been able to clearly define, although we recognize it when we see it. What is this intrinsic property that is clearly present in a human being, a rose or a bacterium—yet, is entirely absent in a piece of polyethylene, an oil globule or a refractory brick?

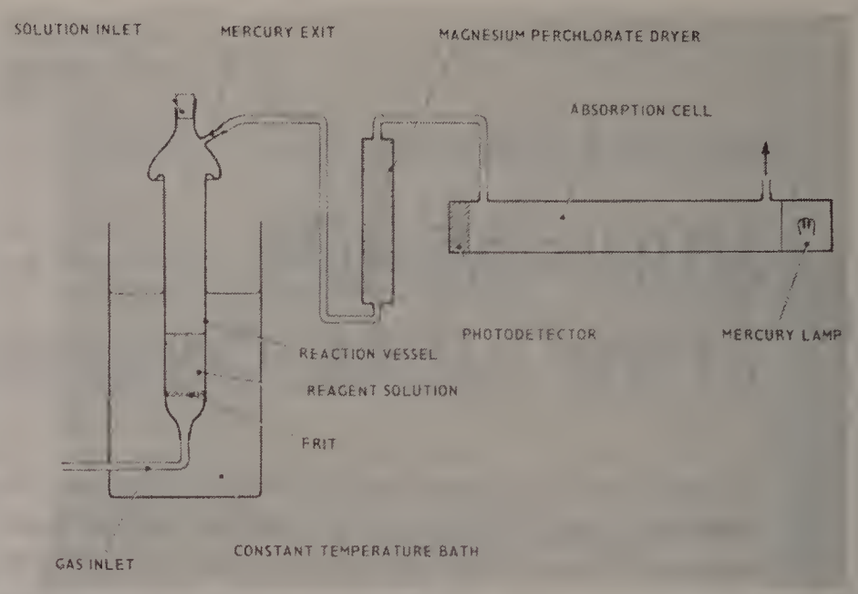
Living things, Prof. Eigen explained, are extremely complex organisms that have an extraordinary degree of molecular order. They are composed of a relatively small number of basic building blocks, which are bonded together in a very specific sequence to form very large molecular structures. All the information required for the organism to assemble these macromolecules is encoded in its nucleic acid molecules RNA and DNA.

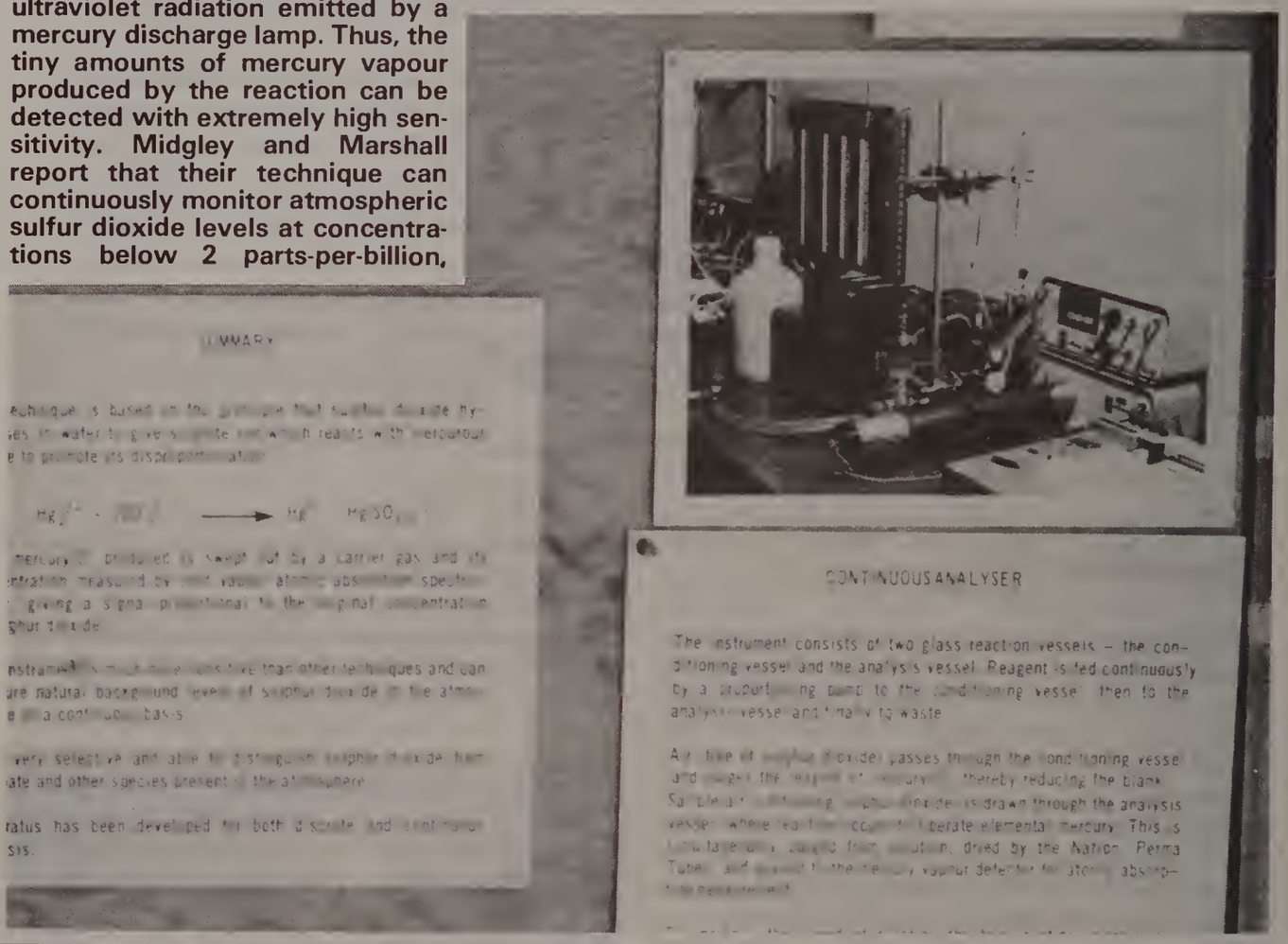
A particular organism is defined by a unique sequence of nucleotide bases in its nucleic acid molecules. The precise sequence is what distinquishes living organisms from each other, and from non-living things. Certain sequences give rise to viable organisms that can survive in a particular environment; the overwhelming majority do not.

The number of alternative sequences of nucleotide bases is so enormous as to preclude the possibility that the correct combination could arise by chance. Prof. Eigen pointed to the simplest nucleic acid unit which has been identified, containing 221 nucleotide base pairs. The number of alternative sequences of

In his opening address, Prof. Manfred Eigen probed the very meaning of life, and how it might have appeared on Earth. He explained that random chemical processes alone could not have given rise to the extraordinary degree of molecular order found in all living cells.

A technique for measuring trace levels of sulfur dioxide was described at the IUPAC Congress in a poster presentation by D. Midgley and G. B. Marshall of the Central Electricity Research Laboratory (in the UK). Unlike conventional flame photometry analysis methods, their new technique of Mercury Displacement Detection responds only to sulfur dioxide (and not to sulfate ions). Their analysis method relies on the hydrolysis of SO_2 to produce sulfite ions in solution. These react with mercurous nitrate to generate metallic mercury. An inert carrier gas sweeps the mercury vapour into an absorption cell, where it strongly absorbs ultraviolet radiation emitted by a mercury discharge lamp. Thus, the tiny amounts of mercury vapour produced by the reaction can be detected with extremely high sensitivity. Midgley and Marshall report that their technique can continuously monitor atmospheric sulfur dioxide levels at concentrations below 2 parts-per-billion,





base pairs, each no more likely to arise by chance than another, is 10^{133}. If the entire universe were used as a liquid-phase reaction vessel, Prof. Eigen noted, there would still be negligible chance of synthesizing a single nucleic acid unit with the correct structure. Yet, even the simplest autonomous bacterial cell contains 4 million nucleotide base pairs! Human beings have about 1000 times greater complexity.

If complexity and molecular order are the intrinsic properties that characterize living things, and if they could not have originated by chance, how did life appear? Prof. Eigen maintains that these features are generated by natural selection of complex biochemical processes necessary for survival. He envisages that the first precursors of living things *must* have been *simple* organisms. Very likely, they utilized inorganic metal ions to catalyze the few reactions necessary for cell reproduction and growth. All the information needed to direct the synthesis of new cell components—information to be passed on to future generations—was encoded on a single nucleic acid strand, very similar to transfer RNA molecules in present-day cells. Even this short strand probably could store more information than initially was needed, and it probably contained repeating sequences of nucleotide bases.

This limited amount of genetic information would be adequate for an organism supplied with copious amounts of nutrients in a "primordial soup" of amino acids and sugars. In such an indulgent environment, it would have made little difference if the cell constructed proteins that were slightly too large or too small, or did not have the ideal structure to serve their necessary function. Soon, conditions became more demanding, and organisms needed to

extend their biochemical capabilities if they were to survive. To successfully adapt to new environments, an organism could no longer tolerate random ordering in its sequence of nucleotide bases.

For viable species to appear, particular sequences of nucleotide bases had to be generated. This could come about by a series of random "errors" made during reproduction of nucleic acid strands. The vast majority of freak offspring produced in this way would not survive, and their particular sequence of nucleotide bases would disappear. A tiny fraction of these mutants might be slightly better suited for survival and, within perhaps 50 generations, would displace the original organism.

Most evolutionary change probably proceeds by such a series of minor genetic "errors", exactly as Charles Darwin had proposed. However, it has become clear that some other mechanism is also at work. Prof. Eigen cited an analogy: if one always advanced by a series of uphill steps, you would eventually reach the top of the hill on which you started—but could not get across the valley to the next hill. During the course of evolution, organisms have been able to cross these "valleys"—developing wings or gills, for example, where these were needed to exploit new ecological niches. The progression of minor genetic "errors" must have been punctuated by an occasional major "blunder" which was to prove advantageous.

For species to survive and adapt, there was an optimal rate for "errors" to be made during reproduction of nucleotide base sequences. They should occur sufficiently often to generate mutants that can cope with changing environmental conditions. On the other hand, the generation of defective offspring should not constitute an unacceptably large loss of the population.

As evolution progressed, a growing amount of genetic information was encompassed within the cell's nucleic acid. The incidence of errors during reproduction of the nucleotide base sequence was increasing correspondingly—to an unacceptable level. It was not long before these organisms were approaching the limit to the amount of genetic information that could be passed onto their offspring. This ceiling posed a very severe restriction, and threatened to halt evolution at a primitive level. The length of nucleic acid strands was limited to about 4500 nucleotide base pairs, which could not encode enough information to specify the composition of enzymes and other complex protein molecules vital to the development of complex organisms. This was the first information crisis!

Today, no organism containing a single strand of nucleic acid has yet been found with more than 4500 nucleotide bases. Simple viruses that have such limited genetic information are not self-sufficient organisms: they exploit the reproductive mechanisms of host bacterial cells and utilize genetic information encoded in the host cell.

To break through this barrier, the first organisms with double-stranded DNA appeared. It was then possible fo the sequence of nucleotide bases to be "proof-read" during replication of the nucleic acid molecule. The rate of reproduction errors could thus be reduced to about 1/300th the error rate in organisms with a single strand of nucleic acid. This opened the way for the evolution of very complex organisms. Genetic information storage and control of protein synthesis were separated into two separate cell functions. DNA became a specialized molecule used for information storage. Segments of its information bank were transferred to messenger RNA molecules, which (with the assistance of transfer RNA molecules) directed biochemical processes necessary for the growth, functioning and reproduction of the cell.

The only vestige of the first ancient organisms, Prof. Eigen believes, is the transfer RNA molecule. He notes that transfer RNA in all present-day organisms has nearly the same 3:1 ratio of the two nucleotide base pairs guanine - cytosine and adenine -uracil. The strands of ribonucleic acid contain no more than 10 000 base pairs, so they could have been reproduced without excessive errors. This suggests to Prof. Eigen that all transfer RNA molecules have a common origin and are remnants of the first "living" organisms that swam or oozed across the Earth.

Is there intelligent life in the laboratory?

The impact of the electronics revolution upon the practice of chemistry was another focal point for speakers at the IUPAC Congress. An increasing number of analytical instruments now utilize microprocessors to control operating conditions for the particular analysis being performed (for example; setting the wavelength, choosing discharge lamps and adjusting instrument sensitivity to measure atomic absorption of one element). At first, microprocessors appeared only in the most sophisticated spectrometers, whereas now they are being incorporated into relatively simple instruments.

Are we approaching a plateau in the application of the microprocessor, asked Dr. C. G. Enke (of Michigan State University, USA), or are we on the threshold of major new developments? In his lecture entitled "Beyond mere automation", Dr. Enke projected that the role of the microprocessor will expand to encompass many additional functions. Electronic monitoring and control systems will take over many routine tasks now performed by human operators, and will interact directly with the human operator at his own level. Such an "intelligent instrument" might calibrate itself automatically; test its own operation, diagnose any problems and inform the operator of the fault; aid the operator in selecting the best conditions to achieve the desired accuracy and throughput, yet avoid interference from other compounds; assist the operator in interpreting data; and refuse to execute commands which might damage the instrument or lead to erroneous results being generated.

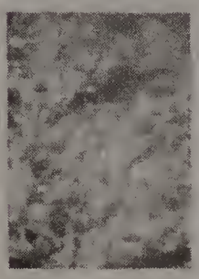
Microprocessors can perform another function of growing importance: they can reject large amounts of redundant or irrelevant data. This capability is

MARINE ALGAE AS METAL BINDERS

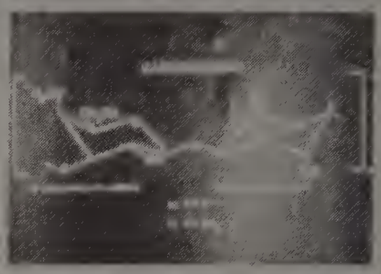
G.J.B. CAJIPE AND E.C. LASERNA
MARINE SCIENCES CENTER, UNIVERSITY OF THE PHILIPPINES

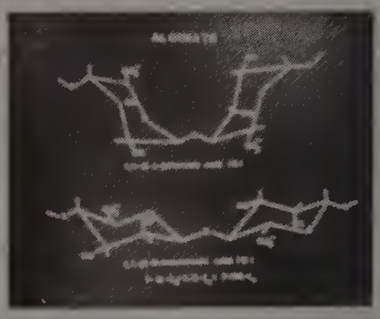
SEAWEEDS EXHIBIT A HIGH AFFINITY FOR MINERAL ELEMENTS

Seaweeds contain a high amount of the alkali minerals and variable amounts of the trace elements, iron, copper and zinc



The high mineral concentration can be attributed to ionic interactions between the cationic mineral elements and the algae's anionic polysaccharidal constituents, such as the highly sulfated carrageenans contained in EUCHEUMA and HYPNEA, and the uronic acid residues that make up alginates of SARGASSUM and TURBINARIA.

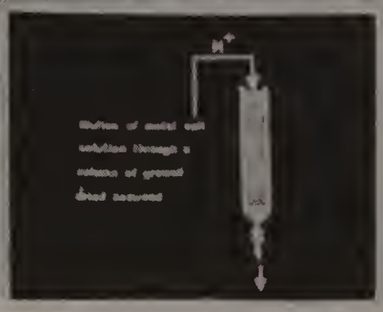




SEAWEEDS, THEREFORE, ARE POTENTIALLY USEFUL AS MINERAL SUPPLEMENTS IN FOOD AND FODDER.

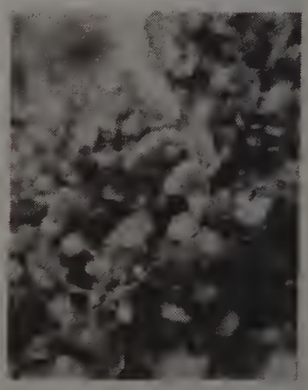
SEAWEEDS ALSO HAVE REMARKABLE AFFINITY FOR HEAVY METALS

Dialysis of carrageenan or alginate solutions against solutions of lead and calcium salts shows that these polysaccharides are effective binders of these heavy metals. The preferential affinity for lead is particularly pronounced in the case of alginate



As shown below, lead can be almost completely removed along with copper from a multi-component metal salt solution.

METAL	% REMOVED
Lead	99.99
Copper	95.83
Cadmium	76.68
Zinc	74.11
Mercury	28.12



Because it is more conveniently handled, SARGASSUM appears to be the seaweed of choice. SARGASSUM also significantly reduces the lead and cadmium present in the effluents discharged into the environment by a lead factory.

SEAWEEDS THEREFORE ARE POTENTIALLY USEFUL IN THE CONTROL OF HEAVY METAL POLLUTION.

especially important for very sophisticated "multi-dimensional" instruments, which achieve greater selectivity and sensitivity by combining two or more separation and analysis methods. At present, the only widely-used multi-dimensional technique is GC/MS, which employs a mass spectrometer to analyze and identify each constituent eluted from a gas chromatography column. By their very nature, multi-dimensional instruments can generate enormous quantities of data (in the case of GC/MS, hundreds of individual mass spectra can be produced for each sample analyzed). Usually, only a small fraction of this data is actually necessary to derive a particular analytical result; the rest merely dilutes and masks the desired information.

By processing huge quantities of raw data and extracting only the useful component, microprocessors could overcome one of the main limitations which formerly restricted multi-dimensional instruments to a few specialized applications. Dr. Enke speculated about new types of multi-dimensional instruments that might gain wide acceptance. These included an advanced stopped-flow instrument to study concentrations of reactants and products in a chemical reaction (employing an array detector to provide complete absorption spectra of the mixture at each stage of the reaction); an emmission/excitation fluorescence spectrometer (providing the spectrum of fluorescence induced by light absorption at each wavelength); and use of a secondary mass spectrometer to study unstable ions resolved by a primary mass spectrometer.

Publishing without printing

The microchip revolution is also expected to exert an enormous influence on the way chemists publish papers and search for information. A growing number of chemists are already using computer terminals to scan the chemical literature, but the main impact of new technology has not yet been felt. A further massive wave of technological change is expected—and could soon be implemented—by editors and publishers of chemistry journals. It was therefore no surprise that most participants at the Symposium for Chemistry Journal Editors (held during the IUPAC Congress) were scanning the horizon.

The ultimate development that many foresee is the "electronic journal", in which each chemist would utilize a computer to select appropriate papers and display them directly on a video screen. To submit a paper, the chemist would type the manuscript directly into the keyboard on his terminal. It would be relayed electronically to the journal editor. Sitting at his word processor console, the Editor would view the manuscript and relay it to the display terminal of the selected referee. The referee's response would be returned to the author, who could then insert corrections and alterations directly in his manuscript. The paper would then be published "on-line"—stored electronically with millions of other papers, books, theses and reports, and made accessible to any reader requesting publications indexed by that combination of key words, author or publication date. A paper might never appear as "hard copy", printed on paper.

Is the "electronic journal" about to surge through the publishing industry, sweeping aside traditonal publication methods—or will its impact be dissipated by resistance from authors and readers? Dr Ivor Williams (Publications Manager for the Royal Society of Chemistry) attacked the question broadside. He had no doubt that the basic technology to establish electronic publishing already exists, and that recent trends pointed towards movement in this direction. However, he felt that electronic publishing would—and should—be developed gradually, and that it would probably never entirely replace conventional printing.

On-line publication still has serious shortcomings, Dr. Williams pointed out, and it would be premature for publishers to abandon the printed journal. In the first place, computer terminals will never offer the portability and convenience of printed material. They cannot be carried on a train or read while eating lunch at the cafeteria. Also, no system has yet been established to charge users of on-line information for access to this material. For publishing to continue unimpeded, there must be a mechanism to provide royalties to authors at some equitable, predetermined rate. Finally, the technical difficulties of composing complex chemical formulas on a display terminal remain to be overcome. It is presently much easier and less time-consuming to draw them on a piece of paper.

The growth of electronic publishing will be an evolutionary process, Dr. Williams projected. It will replace existing publishing methods only when on-line publishing provides a clear advantage. That advantage—if it exists—will be economic, pointed out Dr. Robert Schoenfeld (Managing Editor of the *Australian Journal of Chemistry*). The incentive to introduce electronic publishing, he noted, is not to have a better journal, but a *cheaper* journal.

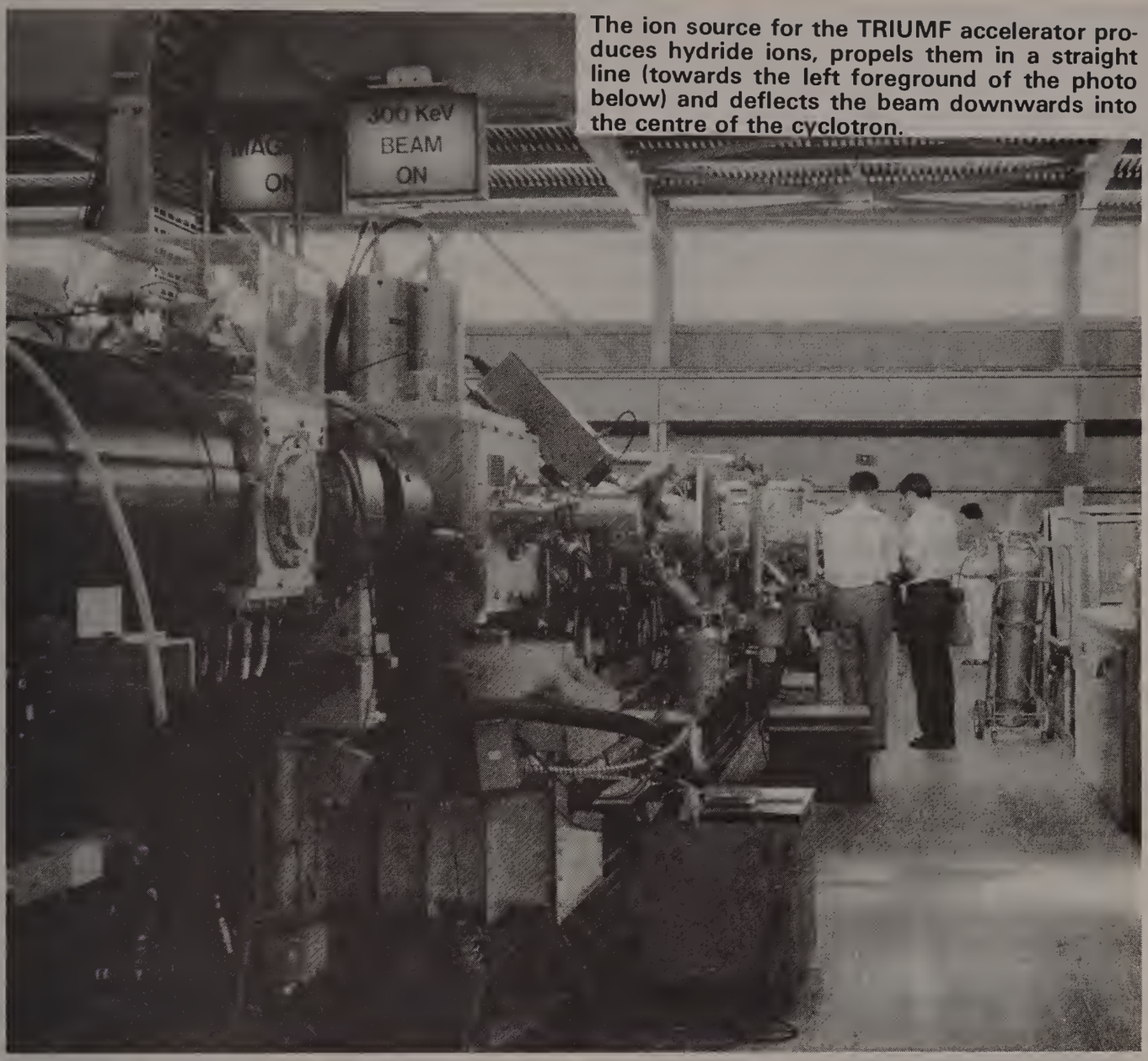
Perhaps electronic publishing will augment, rather than displace, the conventional printed journal. Dr. Cheues Walling (Editor of JACS, the *Journal of the American Chemical Society*) suggested that each publication medium might be best suited to distribute particular types of information. For example, he pointed to two basic types of information sought by readers of JACS. Of the hundreds of chemists who might read any one article in JACS (15 000 copies are published), the vast majority are interested only in the author's main conclusions. Perhaps only a dozen readers want very detailed information about experimental procedures, although this constitutes a major part of most articles. Because such a limited number of individuals desire this specialized information, he reasoned, they should be prepared to go to some other source to get it. That source might be the display terminal at their local library.

The introduction of electronic publishing might resemble a rising tide, rather than a tidal wave. Its impact might hardly be perceptible. As Bob Schoenfeld pointed out, electronic transmission of information is merely another sophisticated tool in the hands of the chemist; but the chemist still has the same job to do. As an analogy, he cited the revolution brought about by television transmission. It is not technological wonders in the television control room that impress the viewers, he emphasized, but the performance of the actors. Television simply allows many more people to see the same performance, and perhaps have a better view of the actor's expressions and gestures. Nothing fundamental has changed in entertainment since the first plays were performed in ancient Greece more than 3000 years ago.

Others agreed. During a conversation that evening, Peter Farago (Editor of *Chemistry in Britain*) pointed to the superficial nature of technological change. "Look", he said, "the same *principles* are used in the modern high-speed printing press as were developed by Gutenberg five hundred years ago. If Gutenberg were brought back to life tomorrow", he told me with absolute conviction, "he would be running a printing plant within two weeks!"

The Indians who originally inhabited Western Canada had a very different perception of how life originated than does Prof. Manfred Eigen, who presented the modern view of biochemical evolution in his opening address at the IUPAC Congress. According to the legend of the Haida Indians, the first human appeared on Earth following the great flood. As the flood receded from the land, now the Queen Charlotte Islands, a raven walked along the sand looking for signs of life. A flash of light caught his eye, and there at his feet was a gigantic clamshell. From this clambered the original Haidas, the first humans. To depict the Haida legend, artist Bill Reid carved the magnificent sculpture shown here (and on the cover of this issue) from a single block of yellow Canadian cedar weighing 4½ tons. It was unveiled in April 1980, and has since been on display at the Museum of Anthropology at the University of British Columbia.

The museum, housing a unique collection of totem poles and artifacts of Indians who lived in Western Canada, is only a short walk from where speakers at the IUPAC Congress presented their recent finding. It was therefore fitting that a drawing depicting the same legend was adopted for the Congress logo.



The ion source for the TRIUMF accelerator produces hydride ions, propels them in a straight line (towards the left foreground of the photo below) and deflects the beam downwards into the centre of the cyclotron.

Killing tumours with exploding pions

Located only three kilometres from the lecture rooms at the University of British Columbia is the particle accelerator and high-energy physics complex comprising the TRIUMF facility (Tri-University Meson Facility). Participants at the IUPAC Congress were invited to tour this unusual complex, which has the capability to undertake a broad range of experiments and commercial projects. The cyclotron particle accelerator can propel ions to sufficiently high energy (up to 500 million electron volts) to produce radioisotopes and short-lived nuclear fragments when they strike atomic nuclei in a target material. The cyclotron has the unusual capability to produce several proton beams simultanously. The energy and intensity of each beam can be varied to suit the requirements of the particular experiment for which it is used.

The heart of the TRIUMF complex is, of course, the cyclotron. This was the one component which could not be seen by tour visitors, although they clambered over the massive pile of concrete blocks which encased the cyclotron (to absorb stray particles). At the top of this concrete hill, we could see the ion source. It generates a beam of hydride ions, accelerates them to an energy of 300 000 electron volts, and injects them into the center of the cyclotron below. There, the negative ions are confined to circular paths by a powerful magnetic field. As the ions are alternately attracted and then repelled by a radiofrequency voltage, they gain velocity and spiral outwards. Eventually, they strike a thin foil, stripping the two loosely-bound electrons. Although the dense proton nucleus is not deflected by the collision, its positive charge interacts with the magnetic field, causing it to be pushed outwards towards an exit port of the cyclotron. By positioning stripping foils at different distances from the centre of the cyclotron, several proton beams can be extracted. At present, three beams are produced.

One proton beam is used to prepare radioisotope tracer compounds of Iodine-123, used to diagnose disorders of the thyroid gland. The high-energy

POSTER

RADIATION SYNTHESIS

R.J. Woods & J.W.T. Spinks
University of Saskatchewan
Saskatoon, Saskatchewan
Canada

RADIATION–INDUCED REACTIONS IN ORGANIC SYSTEMS are initiated by the formation of ions, excited molecules, and free radicals:

A (original molecules) —irradiation→ { A^*, A^+, e^- } → free radicals → chemical products

The ions and excited molecules are generally very short–lived and give rise to rather longer–lived free radicals, which subsequently react forming stable chemical products. For example, irradiation of $HBr + CH_2{=}CH_2$ forms radicals which initiate a chain reaction producing CH_3CH_2Br:

$$Br\cdot + CH_2{=}CH_2 \longrightarrow Br{-}CH_2{-}CH_2\cdot$$
$$Br{-}CH_2{-}CH_2\cdot + HBr \longrightarrow Br{-}CH_2{-}CH_3 + Br\cdot$$

The reaction has a chain length of 10^4 to 10^5 and is terminated by combination of pairs of radicals. This reaction can be initiated by ultraviolet light or by chemically–produced radicals, but ethyl bromide has been produced by the cobalt–60 gamma–ray initiated reaction by the Dow Chemical Company since 1962. The Dow plant has a capacity of one million pounds of ethyl bromide per year using a 1800 Ci cobalt–60 source. About 3% of the production costs are attributable to the radiation facility, which is less costly than alternative chemical catalyst systems.

YIELDS from radiation–induced reactions are given in terms of 'G values' which are the number of molecules of product formed per 100 eV energy absorbed. In other units:

Yield = $G \times M \times 8.3 \times 10^{-4}$ pounds per kilowatt-hour
= $G \times M \times 3.7 \times 10^{+3}$ tons per year per 10^6 kilowatts

where M is the molecular weight of the product.

The greatest return per unit of radiation energy absorbed is obtained when the product GM is large. Large G values are characteristic of chain reactions while large values of M are found with polymers. Most current commercially important radiation chemical processes involve either formation of a product via a free radical chain reaction or modification of a polymeric material.

CURRENT COMMERCIAL APPLICATIONS OF RADIATION-CHEMISTRY include.

Chain reactions

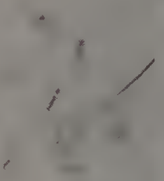
- Synthesis of ethyl bromide from hydrogen bromide and ethylene
- Polymerization of monomers: curing of inks and surface coatings; polymerization of monomer absorbed in a porous solid, e.g. wood or concrete

Polymer modification

- Cross-linking of bulk polymer, e.g. polyethylene wire and cable insulation to increase heat resistance and toughness
- Grafting: polymerization of monomer onto the surface of an existing natural or synthetic polymer, for example to modify the properties of natural fibres.

- Modification of proteins and related molecules.
- sterilization of disposable medical supplies.
- preservation of foods.
- sterilization of sewage.

Dye retention by grafted and untreated fibres



Heat shrinkable connectors

proton beam bombards a cesium target, forming gaseous Xenon-123. This initial product soon decays to I-123. Within hours, the radioisotope is purified, reacted to form the desired compound, and distributed to hospitals throughout Canada. TRIUMF has also embarked on a program to produce a variety of other radioisotopes for local medical research and commercial distribution.

Another proton beam is used to generate negative pions, which are being evaluated as a new radiation treatment for cancer. Preliminary studies have indicated that negative pion beams may be the most selective means to reach and destroy malignant tumours. Short-lived pions pass rapidly through normal tissue overlying the tumour, causing little damage as they are slowed by numerous collisions with atomic nuclei. After they come to rest, usually within the tumour, the unstable pions explode into nuclear fragments which ionize and dissociate molecules in the surrounding tissue. This "depth-charge" effect can destroy cancerous tumours located deep inside the body. By varying the energy of the pion beam, the distance that the particles penetrate can be controlled.

Another proton beam is used to provide thermal (that is, slow-moving) neutrons for Neutron Activation Analysis. It is presently used to analyze trace levels of metals in minerals and environmental samples. The TRIUMF accelerator is the only facility for Neutron Activation Analysis within the province of British Columbia (see "Neutron Activation: a powerful technique becomes available to chemists" in the previous issue of *Chemistry International.*

Nomenclature of tocopherols and related compounds

Provisional recommendations published in 1974 on the nomenclature of tocopherols have been revised incorporating proposals agreed between the Commission on Biochemical Nomenclature (predecessor of JCBN) and the International Union of Nutritional Sciences. The only significant change from the previous version is to recommend that the old trivial names *d*-α-tocopherol, *l*-α-tocopherol and *dl*-α-tocopherol should no longer be used for *RRR*-α-tocopherol, 2-*epi*-α-tocopherol and *all-rac*-α-tocopherol respectively.

The report, which has been prepared by the Joint (IUPAC/IUB) Commission on Biochemical Nomenclature, is due for publication in mid-1982.

The designation of nonstandard classical valence bonding in organic nomenclature *(provisional)*

The use of substitutive nomenclature to name compounds that contain heteroatoms (noncarbon atoms) which can occur in two or more classical valence bonding states requires a way to distinguish between these various valence states. A variety of methods have been used none of which has been completely satisfactory over a broad range of compounds.

These rules provide a single, general method for indicating nonstandard, classical valence states of formally neutral, nonradical skeletal atoms of parent compounds except for cyclic parent structures with cumulative double bonds in addition to the maximum number of noncumulative double bonds. The basic principles of this method were introduced briefly in Section D, as revised for publication in the 1979 edition of the IUPAC Organic Nomenclature Rules (Pergamon Press, 1979). This method is consistent with the fundamental principles of substitutive nomenclature and is directly applicable to naming organic derivatives of inorganic hydrides. It consists of a symbol, λ^n, where n is the classical bonding number defined as the sum of the total number of classical valence bonds to adjacent skeletal atoms, if any, and the number of hydrogen atoms; the λ^n symbol is attached to the locant, where needed, of the heteroatom in the skeletal structure.

This report, prepared by the Commission on Organic Nomenclature, will be published in *Pure & Applied Chemistry* in early 1982.

Nomenclature of Vitamin D *(provisional)*

The recent revival of interest in vitamin D analogues has rendered cumbersome some of the older systems for naming these compounds. This document proposes an extended system of trivial and semisystematic names for the important metabolites of vitamin D.

The trivial names cholecalciferol and ergocalciferol included in the 1966 proposals on Trivial Names of Miscellaneous Compounds of Importance in Biochemistry are retained as alternatives to calciol and ercalciol respectively. The trivial names calcidiol, calcitriol and calcitetrol are reserved for the 3,25-diol, 1,3,25-triol and 1,3,24,25-tetrol respectively. It is hoped that these will replace undesirable abbreviations like $1\alpha,25\text{-}(OH)_2D_3$.

For semisystematic names the most important change from past practice is the recommendation that all stereochemistry in ring A or at C-6 or C-7 should use *R,S,E* or *Z*. This prevents confusion arising from the conformation of ring relative to rings C and D where, for example, frequently the steroid 3β-hydroxy group is in the α region.

The report, which has been prepared by the Joint (IUPAC/IUB) Commission on Biochemical Nomenclature, is due for publication in mid-1982.

IUPAC welcomes comments on its nomenclature recommendations, especially those published as provisional reports. Especially desired are comments about the use of proposed nomenclature in languages other than English. Comments should be sent to the address indicated within eight months of publication of a nomenclature report.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1982

FIRE SAFETY
January 11 - 15. 7th International Conference on Fire Safety. Menlo Park, CA, USA.
(Carlos J. Hilado, Product Safety Corp., 1457 Firebird Way, Sunnyvale, CA 94087, USA.)

THERMAL INSULATION
January 18 - 20. 4th International Conference on Thermal Insulation. Millbrae, CA, USA.
(Carlos J. Hilado, Product Safety Corp., 1457 Firebird Way, Sunnyvale, CA 94087, USA.)

FUEL PIPELINE TECHNOLOGY
January 20 - 22. 5th Meeting & Seminar on Offshore Oil & Gas Pipeline Technology. Basel, Switzerland.
(Access Exhibitions Ltd., 62 Victoria St., St. Albans AL1 3XT, UK).

SOLID WASTES
January 28 - 29. 2nd Annual Symposium on Testing of Hazardous & Industrial Solid Wastes. Orlando, FL, USA.
(Pamela Whiteaker, ASTM, 1916 Race St., Philadelphia, PA 19103, USA.)

CHEMICAL FEEDSTOCKS FROM COAL
February. Int. Symposium "Chem-Coal—A Chemical Feedstock. Johannesburg, South Africa.
(Mr. F. L. D. Cloete, South African Inst. of Chemical Engineers, c/o CERG-CSIR, P. O. Box 395, Pretoria 0001, South Africa.)

WASTE ENGINEERING
February 4 - 5. Water and Waste Engineering in Asia: The 8th Water and Waste Engineering Conference for Developing Countries. Madras, India.
(Prof. R. Pitchai, Centre for Environmental Studies, College of Engineering, Guindy, Madras 600 025, India.)

SOIL SCIENCE
February 8 - 16. International Congress on Soil Science. New Delhi, India.
(Dr. Bouché, Station de Recherche sur la Faune du Sol, 7, rue Sully, 21034 Dijon Cedex, France.)

SULPHUR BACTERIA
February 17 - 18. Discussion Meeting on Sulphur Bacteria. London, UK.
(Miss C. A. Johnson, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, UK.)

OCCUPATIONAL HEALTH
February 20 - 23. International Symposium on Occupational Health Problems in Developing Countries. Ahmedabad, India.
(Dr. S. K. Kashyap, Executive Secretary International Symposium on OHPDC, National Institute of Occupational Health, Meghani Nagar, Ahmedabad 280 016, India.)

HYDROTHERMAL REACTIONS
March. Yamanchi International Symposium on Hydrothermal Reactions. Tokyo, Japan.
(Prof. Shigeyuki Somiya, Director, Laboratory for Hydrothermal Synthesis Research Laboratory of Engineering Materials, Tokyo Institute of Technology, 4259 Nagatsuta, Midori, Yokohama 227, Japan.)

QUANTUM CHEMISTRY
March 8 - 13. International Symposium on Quantum Theory of Condensed Matter. Palm Coast, FL, USA.
(John R. Rabin, 372 Williamson Hall, University of Florida, Gainesville, FL 32611, USA.)

IONISING RADIATION
March 12 - 17. International Symposium on Applications and technology of ionising radiations. Riyadh, Saudi Arabia.
(Raymond C. Barral, Cancer Therapy Institute, King Faisal Hospital, Box 3354, Riyadh, Saudi Arabia.)

UNIVERSITY/INDUSTRY COOPERATION
March 17 - 18. International Symposium on "Research & Industry, a Community?" Paris, France.
(Association Des Anciens Eleves, Ecole Nationale Superieure de Chimie de Paris, Colloque International - Chercheurs et Chefs d'entreprise, comment mieux reussir ensemble? 28, rue Saint-Dominique, F-75007 Paris, France.)

CORROSION
March 22 - 26. International Conference on Corrosion. Houston, TX, USA.
(Conference Coordination, National Association of Corrosion Engineers, POB 218340, Houston, TX 77218, USA.)

ESR OF ORGANIC RADICALS
March 22 - 26. International Conference of Electron Spin Resonance of Organic and Bio-Organic Radicals. Nottingham, UK.
(Dr. J. B. Raynor, Chemistry Department, The University, Leicester LE1 7RH, UK.)

BIOCHEMICAL SEPARATION METHODS
March 23 - June 4. Course on Biochemical Separation Methods. Lectures and laboratory work dealing with various aspects of electrophoresis, chromatographic separation, liquid-phase partition, centrifugation and other means of separating and characterizing cells, virus, proteins and nucleic acids. Closing date for application is 15 January 1982. University of Uppsala, Sweden.
(Secretary Eva Linder, Institute of Biochemistry, University of Uppsala, Box 576, S-75123 Uppsala, Sweden.)

SAFE USE OF SOLVENTS
March 23 - 27. Int. Symposium on the Safe Use of Solvents. Brighton, UK.
(Secretariat, International Symposium on the Safe Use of Solvents, 142 - 144, Oxford Road, Cowley, Oxford OX4 2DZ, UK.)

ELECTROLYTES IN MIXED SOLVENTS
March 28 - April 2. International Symposium on "Thermodynamic Behavior of Electrolytes in Mixed Solvents" to be held at the American Chemical Society 183rd National Meeting. Las Vegas, Nevada, USA.
(William F. Furter, Professor of Chemical Engineering, Royal Military College of Canada, Kingston, Ontario, Canada K7L 2W3.)

AMERICAN CHEMICAL SOCIETY
March 29 - April 2. 183rd American Chemical Society National Meeting. Las Vegas, Nevada, USA.
(American Chemical Society, 1155 16th Street, NW, Washington, DC 20036, USA.)

ION BEAMS
March 29 - April 2. EUCHEM Conference on Chemistry of Ion Beams. Gregynog, UK.
(Prof. J. H. Beynon, F.R.S. Royal Society Research Unit, University of Swansea, Singleton Park, Swansea SA2 8PP, UK.)

WATER POLLUTION
March 29 - April 2. 11th Biennial Conference of the International Association on Water Pollution Research. Cape Town, South Africa.
(Int. Association on Water Pollution Research, Chichester House, 278, High Holborn, London WC1V 7HE, UK.)

UK CHEMICAL CONGRESS
March 30 - April 1. Annual Chemical Congress. Birmingham, UK.
(Chemical Society, Burlington House, London W1V 0BN, UK.)

ANALYSIS OF POLLUTANTS
April 14 - 16. 12th Annual Symposium on the Analytical Chemistry of Pollutants, Amsterdam, The Netherlands.
(Congress Bureau Vrije Universiteit, P.O. Box 7161, 1007 MC Amsterdam, The Netherlands.)

HAZARD ASSESSMENT
April 14 - 16. Symposium on the Assessment of Major Hazards. Manchester, UK.
(Mr. R. Dodds, ICHemE's North West Branch, c/o J. Crosfield & Sons Ltd., P.O. Box 26, Warrington WA5 1AB, UK.)

RESOURCE MANAGEMENT
April 19 - 20. Symposium on Process for the Management and Conservation of Resources. Salford, UK.
(Dr. R. Hughes, Dept. of Chemical Engineering, Salford University, Salford M5 4WT, UK.)

RECYCLING RESIDUES AND WASTE
April 19 - 21. 3rd International Recycling Congress: "Recovery of Energy and Material from Residues and Waste". Berlin, Federal Republic of Germany.
(IRC—International Recycling Congress, Prof. Dr. K. J. Thomé-Kozmiensley, Rhumeweg 14, D-1000 Berlin 37, Federal Republic of Germany.)

CLINICAL CHEMISTRY
April 19 - 22. International Congress on Automation in Clinical Laboratory. Barcelona, Spain.
(Dr. R. Galimany, Sección de Automatización, Laboratorio de Analisis Clínicos, C. S. "Príncipes de Espana", Hospitalet de Llobregat (Barcelona), Spain.)

OPTICAL & INFRARED SPECTROSCOPY
April 21 - 22. Discussion Meeting on New Techniques in Optical and Infrared Spectroscopy. London, UK.
(Miss C. A. Johnson, The Royal Society, 6, Calton House Terrace, London SW1Y 5AG, UK.)

DOPAMINE RECEPTOR AGONISTS
April 21 - 23. Symposium on "Dopamine Receptor Agonists - Medicinal Chemistry, Pharmacology and Clinical Aspects". Stockholm, Sweden.
(Swedish Academy of Pharmaceutical Sciences, Box 1136, S-111 81 Stockholm, Sweden.)

TRACE ELEMENT ANALYSIS
April 21 - 23. 2nd International Workshop on Trace Element Analytical Chemistry in Medicine and Biology. Neuherberg, Federal Republic of Germany.
(Dr. P. Schramel, Gesellschaft für Strah en- und Umweltforschung für Angewandte Physik, Physikalisch-Technische Abteilung, Ingolstädter Landstrabe 1, D-8042 Neuherberg, Federal Republic of Germany.)

WASTE WATER TREATMENT
April 22 - 24. Symposium on New developments in filtration and their applications in potable, industrial and waste water treatment. Antwerp, Netherlands.
(Mr. R. Viroux, Technologisch Instituut, K.VIV, Ingenieurshuis, Jan van Rijswijklaan 58, B-2000 Antwerp, Netherlands.)

SURFACE IONIZATION PHENOMENA
April 26 - 30. EUCHEM Conference on Surface Ionization Phenomena. The Netherlands.
(Prof. G. Dijkstra, University of Utrecht, Analytisch Chemisch Laboratorium, Croesestraat 77A, Utrecht, The Netherlands.)

ANALYTICAL CHEMISTRY
April 27 - 30. Analytica 82. Munchen, Federal Republic of Germany.
(General Secretary, Dr. Rosmarie Vogel, Nussbaumstr. 20, Postfach 20 03 24, D-8000 Munich 2, Federal Republic of Germany.)

STEREOCHEMISTRY
April 30 - May 5. EUCHEM Conference on Stereochemistry. Switzerland.
(Prof. R. Huisgen, Dept. of Organic Chemistry, Ludwig-Maximilians-Universitat, Geschwister-Scholl-Platz 1, 8000 Munich 2, Federal Republic of Germany.)

BIO-ORGANIC CHEMISTRY
May. EUCHEM Conference on Bio-Organic Chemistry. Gregynog, UK.
(Dr. Peter Doyle, I.C.I. Ltd., Plant Protection Division, Jealotts Hill Research Station, Bracknell, Berks, UK.)

RADICAL POLYMERISATION
May. Microsymposium on Radical Polymerisation. Smolenice, Czechoslovakia.
(Dr. E. Borsig, Institute of Polymer Chemistry, SAV, Dúbravska cesta, Bratislava, Czechoslovakia.)

TECHNOLOGY EXCHANGE
May 3 - 6. International Congress on Technology and Technology Exchange. Pittsburgh, USA.
(International Technology Institute, 7125 Saltsburgh Road, Pittsburgh, PA 15235, USA.)

SCIENCE/SOUTH PACIFIC
May 10 - 14. 52nd Conference of the Australian & New Zealand Association for the Advancement of Science. Sydney, Australia.
(Hon. Organising Secretary, 52nd ANZAAS Congress, Macquarie University, North Ryde, N.S.W. 2113, Australia.)

MASS SPECTROMETRY
May 11 - 14. 4th International Symposium on Quantitative Mass Spectrometry in Life Sciences. Ghent, Belgium.
(A. De Leenheer, Symposium Chairman, Laboratoria voor Medische Biochemie en voor Klinische Analyse, De Pintelaan 135, B-9000 Ghent, Belgium.)

GEOCHEMICAL EXPLORATION
May 12 - 14. 9th Int. Geochemical Exploration Symposium. Saskatchewan, Canada.
(V. Sopuck, Saskatchewan Research Council, 30, Campus Drive, Saskatoon, Saskatchewan, Canada S7N OX1.)

FOOD PROCESSING
May 15 - 20. Food Conference 1982. Singapore.
(The Conference Secretariat, Food Conference 1982, Singapore Professional Centre, Block 23, 129-B, Outram Park, Singapore 0316.)

METAL CLUSTERS
May 20 - 21. Discussion Meeting on Metal Clusters in Chemistry. London, UK.
(Miss C. A. Johnson, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG.)

WORLD ENERGY CONGRESS
May 23 - 27. World Energy Congress. Knoxville, TN, USA.
(Dr. S. McCullough, Energy Opportunities Consortium, POB 2229, Knoxville, TN 37901 USA.)

MOLTEN SALTS
May 24 - 28. EUCHEM Conference on Molten Salts. France.
(Dr. M. Gaune-Escard, Laboratoire de Dynamiq et Thermophysique de Fluides, Universite de Provence, Centre de Saint-Jerome, Rue Henri Poincare, 13397 Marseille, Cedex, France.)

COMPUTERS IN CHEM. ENGINEERING
May 25 - 27. CHEMCOMP 82: Symposium on Chemical Process Analysis and Design using Computers. Antwerp, Belgium.
(Symposium CHEMCOMP 82, c/o K.VIV, Jan Van Rijswijcklaan 58, B-2000, Antwerp, Belgium.)

CATALYSIS
May 26 - 29. 8th Canadian Symposium on Catalysis. Waterloo, Ontario, Canada.
(Jana Karger, Symposium Secretary, 8th Canadian Symposium on Catalysis, University of Waterloo, Ontario, Canada N2L 3G1.)

REACTIONS OF ONE CARBON MOLECULES
May 31 - June 3. International Symposium on Catalytic reactions of one carbon molecules. Belgium.
(Dr. R. Schoonheydt, Centrum voor Oppervlakte- en Colloidale, Scheikunde, KU Leuven, De Croylaan, 42, B-3030 Heverlee (Leuven) Belgium.)

CARBOHYDRATE SYNTHESIS
June. EUCHEM Conference on Synthesis of low molecular weight carbohydrates of biological significance. Sweden.
(Prof. Per J Garegg, Department of Organic Chemistry, Arrhenius Laboratory, University of Stockholm, S-106 91 Stockholm, Sweden.)

ZIRCONIUM
June. 6th International Conference on Zirconium. Vancouver, Canada.
(Meetings Department, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.)

ISOTOPICALLY-LABELED COMPOUNDS
June 6 - 11. International Symposium on the Synthesis and Applications of Isotopically Labeled Compounds. Missouri, USA.
(Dr. Alexander Susàn, Scientific Secretary, International Symposium on the Synthesis and Applications of of Isotopically Labeled Compounds, Midwest Research Institute, 425 Volker Boulevard, Kansas City, MI 64110, USA.)

CHEMICAL ENGINEERING
June 6 - 12. 20th Chemical Engineering Exhibition Congress and the International Meeting of Chemical Engineering. (ACHEMA 82): Chemical engineering, corrosion and biotechnology. Frankfurt am Main, Federal Republic of Germany.
(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt am Main, Federal Republic of Germany.)

SOLID STATE CHEMISTRY
June 7 - 9. 2nd European Conference on Solid State Chemistry. Eindhoven, Netherlands.
(Ir. H. J. M. Heijligers, Eindhoven University of Technology, POB 513, 5600 MB Eindhoven, The Netherlands.)

INDUSTRIAL MICROORGANISMS
June 7 - 11. 4th International Symposium on the Genetics of Industrial Microorganisms. Kyoto, Japan.
(GIM Japan National Committee, c/o Microbiology Research Foundation, 2-4-16 Yayoi, Bunkyo-Ku, Tokyo 113, Japan.)

LIQUID CHROMATOGRAPHY
June 7 - 11. 6th International Symposium on Column Liquid Chromatography. Philadelphia, USA.
(R. A. Barford, ERRC-SEA, U.S. Dept. of Agriculture, 600 East Mermain La., Philadelphia, PA 19118, USA.)

HYDROGEN ENERGY
June 13 - 17. 4th World Hydrogen Energy Conference. Los Angeles, CA, USA.
(Dr. W. D. van Vorst, Chairman Int. Association for Hydrogen Energy, POB 248266, Coral Gabels, FL 33124, USA.)

QUANTUM CHEMISTRY
June 14 - 19. 4th International Congress in Quantum Chemistry. Uppsala, Sweden.
(Uppsala Quantum Chemistry Group, Box 518, S-751 20 Uppsala, Sweden.)

IONIZED ATOMS
June 14 - 27. NATO Adanced Study Institute course on Atomic Physics of Highly Ionized Atoms. (S.82/35). Cargese, France.
(Prof. R. Marrus, Physics Dept., University of California, Berkeley, CA 94720, USA.)

POLYMER LATEX & EMULSIONS
June 15 - 17. International Conference on Polymer Latex and Emulsions. London, UK.
(Mr. R. H. Craven, Plastics and Rubber Institute, 11 Hobart Place, London SW1W OHL, UK.)

ENZYMES
June 16 - 17. Discussion Meeting on Industrial and Diagnostic Enzymes, London, UK.
(Miss C. A. Johnson, The Royal Society, 6, Carlton House Terrace, London SW1Y 5AG, UK.)

SPECTROSCOPY/CHROMATOGRAPHY
June 17 - 18. World Spectroscopy/ Chromatography Conference. Nice, France.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

MEDICINAL CHEMISTRY
June 20 - 24. Medicinal Chemistry Symposium. Toronto, Canada.
(Leslie Humber, North American Medicinal Chemistry Symposium, c/o Ayerst Laboratories, P.O. Box 6115, Montreal, Quebec, Canada H3C 3J1.)

CRUDE OIL RECOVERY
June 21 - July 4. NATO Advanced Study Institute course on Heavy Crude Oil Recovery. (S.82/30). METU, Ankara, Turkey.
(Prof. E. Okandan, Mining & Petroleum Engineering Dept., METU, Ankara, Turkey.)

STORAGE OF BULK CHEMICALS
June 22 - 24. 4th International Conference and Exhibition on the Transportation Handling and Storage of Bulk Chemicals—MariChem 82. Amsterdam, Netherlands.
(Conference Secretariat, 2 Station Road, Rickmansworth, Herts WD3 1QP, UK.)

SOLID/LIQUID INTERFACES
June 22 - 30. 6th International Summer Conference on Chemistry of Solid/Liquid Interfaces including the International Symposium on Precipitation and Interfacial Phenomena in Mineralization in Biological or Biopolymer Matrices. Cavtat/ Dubrovnik, Yugoslavia.
(Dr. Velimir Pravdić, VI Summer Conference Chemistry, "Rudjer Bosković" Institute, POB 1016, YU 41001 Zagreb, Yugoslovia.)

ENVIRONMENTAL POLLUTION
June 28 - 29. 3rd European Conference on Environmental Pollution. Nice, France.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

POLYMER COLLOIDS
June 29 - July 12. NATO Advanced Study Institute course on Polymer Colloids (S.82/1). Bristol, UK.
(Dr. G. W. Poehlein, School of Chemical Engineering, Inst. of Technology, Atlanta, GA 30332, USA.)

MEDICAL CHEMISTRY
July. 18th International Meeting on Medicinal Chemistry. Rennes, France.
(Prof. J. Huet, Faculte de Pharmacie, Laboratoire de chinie pharmaceutique, Avenue du Professeur L. Bernard, F- 35043, Rennes Cedex, France.)

SOLUTE - SOLVENT INTERACTIONS
July 4 - 10. 6th International Symposium on Solute-Solute - Solvent Interactions. Minoo, Osaka Prefecture, Japan.
(Prof. Hitoshi Ohtaki (Department of Electronic Chemistry, Tokyo Institute of Technology at Nagatsuta, Nagatsuta-cho, Midori-ku, Yokohama, 227 Japan.)

REACTION MECHANISMS
July 5 - 9. 3rd International Conference on Mechanisms of Reactions in Solution. Canterbury, UK.
(Dr. John F. Gibson, Secretary (Scientific), The Royal Society of Chemistry, Burlington House, London W1V OBN, UK.)

INORGANIC STEREOCHEMISTRY
July 6 - 9. International Conference on Inorganic Stereochemistry. University of Reading, UK.
(Dr. J. F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V OBN, UK.)

COMPUTERS IN CHEMICAL RESEARCH
July 6 - 11. 6th International Conference on Computers in Chemical Research and Education (ICCCRE). Washington, DC, USA.
(Dr. Stephen R. Heller, Chairman, 6th ICCCRE, EPA, MIDSD, PM-218, 401 M Street, SW, Washington, DC 20460, USA.)

PHYSICAL ORGANIC CHEMISTRY
July 11 - 16. 6th IUPAC Conference on Physical Organic Chemistry. Louvain-laNeuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, B-1348 Louvain-laNeuve, Belgium.)

PLANT TISSUE & CELL CULTURE
July 11 - 16. 5th International Congress of Plant Tissues & Cell Culture. Tokyo and Lake Yamana.
(Masatoshi Iwata, Faculty of Agriculture, Univ. of Tokyo, Bunkyoko, Tokyo 113, Japan.)

LANTHANIDES
July 11 - 25. NATO Advanced Study Institute course on Systematics and the Properties of the Lanthanides. (S.82/31). Braunlage, Federal Republic of Germany.
(Prof. S. F. Sinha, Hahn Meitner Institute, Glienicker Str. 100, 1000 Berlin 39, Federal Republic of Germany.)

CHITIN AND CHITOSAN
July 12 - 14. 2nd International Conference on Chitin and Chitosan. Sapporo, Japan.
(Dr. S. Hirano, Department of Agricultural Biochemistry, Tottori University, Tottori 680, Japan.)

MACROMOLECULES
July 12 - 16. IUPAC Macromolecular Symposium. Amherst, MA, USA.
(James C. W. Chien, Dept. of Polymer Science and Engineering, University of Massachusetts, Amherst, MA 01003, USA.)

CORRELATION ANALYSIS IN ORGANIC CHEMISTRY
July 18 - 23. 2nd Euchem Conference on Correlation Analysis in Organic Chemistry. Hull, UK.
(Dr. John F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

SELECTIVE POLYMER SORBENTS
July 19 - 22. 23rd Prague Microsymposium "Selective Polymer Sorbents". Prague, Czechoslovakia.
(Dr. F. Svec, c/o Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, 162 06 Prague 616, Czechoslovakia.)

NON-AQUEOUS SOLUTIONS
July 19 - 23. 8th International Conference on Non-aqueous solutions. Nantes, France.
(Pham Van Huong, Laboratoire de Spectroscopie Infrarouge et Raman, University de Bordeaux I. 351 Cours de la Liberation - 33405, Talence, France.)

PHOTOCHEMISTRY
July 25 - 30. 9th IUPAC Symposium of Photochemistry. Pau, France.
(Prof. J. Joussot-Dubien, Laboratoire de Chimie Physique A, Université de Bordeaux I, F-33405 Talence, France.)

MARINE NATURAL PRODUCTS
July 26 - 30. 4th International Symposium on Marine Natural Products. Tenerife, Spain.
(Prof. A. G. González, Department of Organic Chemistry, University of La Laguna, Tenerife, Canary Islands, Spain.)

ATOMIC SPECTROSCOPY
July 27 - 30. 14th Conference of the European Group for Atomic Spectroscopy. Liège, Belgium.
(Mr. N. Grevesse, BFS-Group, University of Liège, Tilman B15, B-4000, Liège, Beligum.)

ION CHEMISTRY
August. EUCHEM Conference on Ionic Chemistry: Gaseous versus solvent ions. Italy.
(Prof. F. Cacace, Insituto di Chimica, Farmaceutica e Tossicologica Cattedra di Chimica Generale ed Inorginac, Universita di Roma, Rome, Italy.)

BIOPHYSICS
August 2 - 27. Summer course on Biophysics, including lectures and seminars presenting biophysics topics from a molecular and a biological approach. The interdisciplinary course is aimed at research workers from developing countries, as well as graduate and post-doctoral students from developed countries. Closing date for requesting participation grants is 31 January. Miramare - Trieste, Italy.
(International Centre for Theoretical Physics, P.O. Box 586, I-34100 Trieste, Italy.)

MARINE CHEMISTRY
August 2 - 13. Joint Oceanographic Assembly. Halifax, Canada.
(Mr. Leo O'Quinn, Executive Secretary, JOA-82, 240 Sparks Street, 7th Floor West, Ottawa, Ontario, K1A 0E6, Canada.)

NATURAL PRODUCTS
August 2 - 7. 13th Int. Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs. Jeanne Beck, Symposium Secretariat - S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa.)

RADIATION INSTRUMENTATION
August 9 - 13. International Conference on X-Ray and VUV Synchrotron Radiation Instrumentation. Hamburg, Federal Republic of Germany.
(Mr. B. Buras, Riso National Laboratory, DK-4000 Roskilde, Denmark.)

BIOCHEMISTRY
August 15 - 21. 12th Int. Congress of Biochemistry. Perth, Australia.
(Prof. B. N. Preston, Biochemistry Dept., Monash University, Clayton, Victoria 3168, Australia.)

EFFLUENTS OF COAL-FIRED PLANTS
August 16 - 18. International Conference on Coal-Fired Power Plants and the Aquatic Environment. Copenhagen, Denmark.
(Mr. P. Schjodtz Hansen, Director V K I (Water Quality Institute) 11, Agern Alle, DK-2970 Horsholm, Denmark.)

COAL CONVERSION
August 16 - 20. International Coal Conversion Conference. Pretoria, South Africa.
(The Symposium Secretariat S.244, International Coal Conversion Conference, Council for Scientific and Industrial Research, P.O. Box 395, 0001 Pretoria, Republic of South Africa.)

METALS AND ALLOYS
August 16 - 20. 6th International Conference on the Strength of Metals and Alloys. Melbourne, Australia.
(The Director, Australasian Institute of Metals, 191 Royal Parade, Parkville, Victoria 3052, Australia.)

SYNTHETIC NUCLEIC ACIDS
August 16 - 20. International Conference on Synthetic Oligonucleotides in Molecular Biology. Uppsala, Sweden.
(Dr. J. B. Chattopadhyaya, Department of Microbiology, University of Uppsala, The Biomedical Center, Box 581, S-751 23 Uppsala, Sweden.)

ELECTRON MICROSCOPY
August 17 - 24. 10th International Congress of Electron Microscopy. Hamburg, Federal Republic of Germany.
(Dr. Schimmel, Batelle Inst. Postfach 900160, 6 Frankfurt M-90, Federal Republic of Germany.)

PLANETARY ATMOSPHERES
August 17 - 28. International Conference on Origin and Evolution of Planetary Atmospheres. Hamburg, Federal Republic of Germany.
(Mr. S. Ruttenberg, Int. Assoc. of Meteorology & Atmospheric Physics Secretariat, NCAR. P.O. Box 3000, Boulder, CO 80307, USA.)

OXIDATION REACTIONS
August 18 - 22. 2nd International Specialists Meeting of the Combustion Institute on Oxidation. Budapest, Hungary.
(Dr. Tamas Vidoczy, Executive Secretary, Second International Specialists Meeting of the Combustion Institute on Oxidation, Central Research Institute for Chemistry, H-1525 Budapest, P.O. Box 17, Hungary.)

BIOLOGICAL SCIENCE
August 22 - 27. General Assembly and Scientific Symposia of the Int. Union of Biological Sciences. Ottawa, Canada.
(Dr. I. J. McDonald, Secretary, CNC/IUBS, Division of Biological Sciences, National Research Council, Ottawa, Canada K1A OR6.)

ORGANIC SYNTHESIS
August 22 - 27. 4th International Conference on Organic Synthesis. Tokyo, Japan.
(Prof. Teruaki Mukaiyama, Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.)

CARBOHYDRATES
August 22 - 28. 11th International Carbohydrate Symposium. Vancouver, Canada.
(Dr. G. C. S. Dutton, Department of Chemistry, University of British Columbia, Canada V6T 1Y6.)

THERMAL ANALYSIS
August 22 - 28. 7th International Conference on Thermal Analysis. Kingston, Ontario, Canada.
(Chairman, Organizing Committee, seventh ICTA, Dunlop Research Centre, Sheridan Park Research Community, Mississauga, Ontario, Canada L5K 1Z8.)

CHEMISTRY/AUSTRALIA
August 23 - 27. 7th National Convention of The Royal Australian Chemical Institute. Canberra, Australia.
(Dr. J. H. Bradbury, Chairman, 7NC, Chemistry Department, Australian National University, Canberra, A.C.T. Australia.)

COORDINATION CHEMISTRY
August 23 - 27. 22nd Int. Conference on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010 Hungary.)

MASS SPECTROMETRY
August 30 - September 3. 9th Int. Mass Spectrometry Conference. Vienna, Austria.
(INTERCONVENTION , P.O. Box 80, A-1107 Vienna, Austria.)

MYCOTOXINS AND PHYCOTOXINS
August 31 - September 2. 5th Int. Symposium (IUPAC) on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Department of Microbiology, Royal Dental College, Juliane Mariesvej 30[2], DK-2100 Copenhagen O, Denmark.)

AIR - SEA GAS EXCHANGE
August/September. NATO Advanced Study Institute course on Air - Sea Exchange of Gases and Particles (S.82/1). USA.
(Dr. P. S. Liss, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK.)

GAS KINETICS
August 23 - 27. 7th International Symposium on Gas Kinetics. Göttingen, West Germany.
(Prof. J. Troe, Institut für Physikalische Chemie der Universität Göttingen, Tammanstrasse 6, 3400 Göttingen, Federal Republic of Germany.)

MULTINUCLEAR MAGNETIC RESONANCE
August 23 - September 3. NATO Advanced Study Institute course on The Multinuclear Approach to Magnetic Resonance (S.82/6). Stirling, Scotland, UK.
(Prof. J. B. Lambert, Dept. of Chemistry, Northwestern University, Evanston, IL 60201, USA.)

CHEMICAL ENGINEERING
August 24 - 26. 10th Australasian Conference on Chemical Engineering—CHEMECA '82. Sydney, Australia.
(The Conference Manager, The Institution of Engineers, Australia, 11 National Circuit, Barton ACT 2600, Australia.)

POLYMER STRUCTURE & PROPERTIES
August 29 - September 2. Symposium on the Interrelations between Processing, Structure & Properties of Polymeric Materials. Athens, Greece.
(Prof. P. S. Theocaris, Chair of Applied Mechanics, National Technical University of Athens, Athens, Greece.)

PESTICIDE CHEMISTRY
August 29 - September 4. 5th Int. Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2-1 Hirosawa Wako-shi Saitama Pref 351, Japan.)

PLANT GROWTH
August 29 - September 4. 21st International Horticultural Congress. Hamburg, Federal Republic of Germany.
(21st International Horticultural Congress, Hamburg Messe und Congress GmbH, P.O. Box 30 23 60, D-2000 Hamburg 36, Federal Republic of Germany.)

TRANSIENT SPECIES
Autumn. Euchem Conf. on Short lived species in inorganic chemistry and their stabilization. Federal Republic of Germany.
(GDCh-Geschäftsstelle, Postfach 90 04 40, 6000 Frankfurt/Main 90, Federal Republic of Germany.)

FOOD PROCESSING & POLLUTION
September. CIIA/METE Symposium on Food Industry and the Environment. Budapest, Hungary.
(Prof. J. Hollo, Central Research Inst. for Chemistry, Budapest, Pf. 17, H-1525, Hungary.)

THEORETICAL CHEMISTRY
September. International Symposium on Theoretical Organic Chemistry. Dubrovnik, Croatia, Yugoslavia.
(Dr. Ante Graovac, Institute "R. Bosković", POB 1016, 41001 Zagreb, Yugoslavia.)

IONIZED GASES
September 1 - 3. 6th Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases (ESCAMPIG). Oxford, UK.
(Dr. R. W. P. McWhirter, Rutherford Laboratory, Chilton, Didcot OX11 0QX, UK.)

MYCOTOXINS AND PHYCOTOXINS
September 1 - 3. 5th International IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.
(5th International IUPAC Symposium, c/o Verein Österreichischer Chemiker, A-1010 Vienna, Eschenbachgasse 9, Österreich/Austria.)

ECOLOGY
September 2 - 8. International Congress of Ecology. Poland.
(Prof. S. Ulfstrand, Sec. Gen. INTECOL, Dept. of Zoology, Box 561, S-751 22 Uppsala, Sweden.)

HORMONAL STEROIDS
September 5 - 10. 6th International Congress on Hormonal Steroids. Jerusalem, Israel.
(Secretariat, PO Box 29784, Tel Aviv 61 297, Israel.)

CHEMICAL STRUCTURE - BIOLOGICAL ACTIVITY
September 6 - 9. 4th European Symposium on Chemical Structure and Biological Activity: Quantitative Approaches. Bath, UK.
(Dr. J. C. Dearden, School of Pharmacy, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF, UK.)

PREPARATION OF HETEROGENEOUS CATALYSTS
September 6 - 9. 3rd Int. Symposium on the Scientific Bases for the Preparation of Heterogeneous Catalysts. Louvain-la-Neuve, Belgium.
(Prof. B. Delmon, Université Catholique de Louvain, Groupe de Physico-Chimie Minerale et de Catalyse, Place Croix du Sud 1, B-1348 Louvain-la-Neuve, Belgium.)

CHROMATOGRAPHY
September 6 - 10. 14th International Symposium on Chromatography. London, UK.
(Gesellschaft Deutscher Chemiker, Abteilung Fachgruppen, Postfach 90 04 40, D-6000 Frankfurt (Main) 90, Federal Republic of Germany.)

HEAT TRANSFER
September 6 - 10. 7th International Heat Transfer Conference. München, Federal Republic of Germany.
(DECHEMA, Postfach 97 01 46, D-6000 Frankfurt, Federal Republic of Germany.)

ORGANIC SULPHUR CHEMISTRY
September 6 - 10. 10th International Symposium on the Organic Chemistry of Sulphur. University College North Wales. Bangor, UK.
(Dr. J. F. Gibson, The Royal Society of Chemistry, Burlington House, London W1V 0BN, UK.)

RAMAN SPECTROSCOPY
September 6 - 12. 8th International Conference on Raman Spectroscopy. Bordeaux, France.
(Prof. J. Lascombe, Université de Bordeaux 1, 351, cours de la Libération, 33405 Talence Cedex, France.)

CHEMICAL THERMODYNAMICS
September 7 - 10. 7th International Conference on Chemical Thermodynamics. London, UK.
(Prof. M. L. McGlashan, Department of Chemistry, University College of London, 20 Gordon Street, London WC1H 0AJ, UK.)

AMERICAN CHEMICAL SOCIETY
September 12 - 17. 184th National Meeting of the American Chemical Society. Kansas City, MI, USA.
(A. T. Winstead, American Chemical Society, 1155 16th Street, NW, DC 20036, USA.)

THERMODYNAMICS-CALORIMETRY
September 13 - 17. 2nd Czechoslovak Conference on Calorimetry. Liblice and Prague, Czechoslovakia.
(Prof. Dr. Ing, Jirí Pick, DrSc. Dept. of Physical Chemistry, Institute of Chemical Technology, 166 28 Prague 6, Suchbatarova 5, Czechoslovakia.)

CHEMICAL ENGINEERING
Septembe 14 - 16. 3rd Meeting of the Chemical Engineers in Italy, Yugoslavia and Austria. Raiffeisenhof Graz, Austria.
(Prof. Dr. F. Moser, Institut für Grundlagen der Verfahrenstechnik, TU Kopernikusgasse 24, A-8010 Graz, Austria.)

FOOD TECHNOLOGY
September 18 - 23. 6th International Congress of Food Science and Technology. Dublin, Ireland.
(Dr. R. L. Joseph, c/o, An Foras Taluntais, Dunsinea, Castleknock, Co. Dublin, Ireland.)

CLINICAL BIOCHEMISTRY
September 19 - 24. 2nd Asian Pacific Congress of Clinical Biochemistry. Republic of Singapore.
(Secretariat Singapore Professional Centre, 129B Block 23, Outram Park, Singapore 316, Republic of Singapore.)

FOOD RESEARCH
September 20 - 23. IUFoST Symposium on Food Research and Data Analysis. Oslo, Norway.
(Dr. H. Martens, Norwegian Food Research Inst., P.O. Box 50, N. 1432, As-NLH, Norway.)

BIOMASS UTILIZATION
September 20 - 30. NATO Advanced Study Institute course on Biomass Utilization (S.81/23). W. Virginia, USA.
(Dr. H. Sobel, Biosources Digest, P.O. Box 1979, Santa Monica, CA 90406, USA.)

FOLIC ACID DERIVATIVES
September 21 - 24. 7th International Symposium on Pteridines and folic acid derivatives. St. Andrews University, Scotland, UK.
(Prof. H. C. S. Wood, Department of Pure and Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL, Scotland, UK.)

MAGNETIC CIRCULAR DICHROISM
September 27 - 30. EUCHEM Conference on Magnetic Circular Dichroism. Belgium.
(Prof. C. Gorller-Walrand, Katholieke Universiteit te Leuven, Departement Scheikunde Afdeling Anorganische Analytische Scheikunde, Celestijnenlaan 200F, 3030 Heverlee, Belgium.)

ION MOTION THROUGH MEMBRANES
September 27 - October 1. International meeting of the Societe de Chimie Physique on Physical Chemistry of Transmembrane Ion Motions. Paris, France.
(Dr. C. Troyanowsky, Gen. Secretary, Societe De Chimie Physique, 36th Intern. meeting, 10, rue Vauquelin, F-75231 Paris Cedex 05, France.)

PERICYCLIC REACTIONS
September 27 - October 1. EUCHEM Conference on Pericyclic Reactions. Italy.
(Prof. A. Dondoni, Istituto Chimico, Universita of Ferrara, 44100 Ferrara, Via L. Borsari, Italy.)

WATER POLLUTION
October. Water Pollution Control Federation Int. Convention. Saint Louis, MI, USA.
(R. A. Canham, 3900 Wisconsin Avenue NW, Washington, DC 20016, USA.)

THERMOPHYSICAL PROPERTIES
October 1 - 9. 8th European Conference on Thermophysical Properties. Baden-Baden, Federal Republic of Germany.
(H. E. Schmidt, 8 ETPC, Postfach 2266, D-7500, Karlsruhe, Federal Republic of Germany.)

CODATA
October 3 - 8. 8th International CODATA Conference. Kozubnik, Poland.
(Prof. A. Bylicki, Institute of Physical Chemistry, Polish Academy of Sciences, ul. Kasprzaka 44/52, 01 224 Warsaw, Poland.)

CHEMICAL REACTION ENGINEERING
October 4 - 6. International Symposium "Chemical Reaction Engineering". Boston, MA, USA.
(Prof. James Wei, Dept. of Chemical Engr. Mass. Inst. of Tech., Cambridge, MA 02139, USA.)

RADIATION PROCESSING
October 4 - 8. 4th International Meeting on Radiation Processing. Dubrovnik, Yugoslavia.
(Dr. V. Markovic, Laboratory of Solid State Physics and Radiation Chemistry 030, Boris Kidric Institute of Nuclear Science, Vinca. POB 522, YU-11001 Belgrade, Yugoslavia.)

ENVIRONMENTAL POLLUTION
October 5 - 6. 3rd International Symposium on Environmental Pollution. Ontario, Canada.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

SPECTROSCOPY/CHROMATOGRAPHY
October 7 - 8. International Spectroscopy/ Chromatography Conference. Ontario, Canada.
(Alena Enterprises of Canada, 209 Dover Road, Cornwall, Ontario, Canada.)

DEGRADATION OF POLYMERS
October 11 - 14. EUCHEM Conference on Degradation processes in natural polymers. The Netherlands.
(Dr. J. Lodewijks, c/o Central Research Laboratory of Art and Science, Gabriel Metsustraat 8, Amsterdam, The Netherlands.)

CORROSION
October 18 - 22. Conference of the European Federation for Corrosion (EUROCORR '82). Budapest, Hungary.
(Scientific Society of Mechanical Engineers, P.O. Box 451, H-1372 Budapest, Hungary.)

LIQUID CRYSTALS
October 27 - 28. Discussion Meeting on The Physics, Chemistry and Applications of Liquid Crystals. London, UK.
(Miss C. A. Johnson, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, UK.)

CHEMISTRY RELATING TO AGRICULTURE
December 6 - 10. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II). Manila, Phillipines.
(Dr. Charles. S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington, DC 20036, USA.)

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ORGANIC FREE RADICALS
EUCHEM Conference on Organic Free Radicals. Federal Republic of Germany.
(Prof. R. Sustman, Universitat Essen-Gesamthochschule, Universitatsstrasse 2, Postfach 6843, 4300 Essen, Federal Republic of Germany.)

COMPUTERS IN CHEMISTRY
EUCHEM Conference on Computers in Chemistry from conception to production. France.
(Dr. M. Le Grand, Centre de Researche, Roussel Uclaf, 102 Route de Noisy, 03 Romain ville, France.)

OILS, FATS & WAXES
February 13 - 17. International Conference on Oils, Fats & Waxes. Auckland, New Zealand.
(Mr. S. G. Brooker, Department of Chemistry, University of Auckland, Private Bag, Auckland, New Zealand.)

HYDRAULIC CEMENTS
February 16 - 17. Discussion Meeting on Technology in the 1990s: Developments in the Science and Technology of Hydraulic Cements. London, UK.
(Miss C. A. Johnson, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, UK.)

AMERICAN CHEMICAL SOCIETY
March 20 - 25. 185th ACS National Meeting. Seattle, USA.
(A. T. Winstead, ACS, 1155 - 16th St. N.W., Washington, DC 20036, USA.)

EFFLUENT TREATMENT
April. Symposium on Effluent Treatment in the Process Industries. Loughborough, UK.
(Dr. J. J. Stenhouse, Dept. of Chemical Engin. University of Technology, Loughborough, UK.)

LASER CHEMISTRY
April. EUCHEM Conference on Laser Chemistry. Belgium.
(Prof. X de Hemptinne, Katholieke Universiteit te Leuven, Laboratorium voor Fysico chemie en Kinetica, Celestijnenlaan 200F, 3030 Heverlee, Belgium.)

CHEMICAL ENGINEERING
April 11 - 13. 6th International Congress in Scandinavia on Chemical Engineering. Copenhagen, Denmark.
(Bella Center A/S, Center Boulevard, DK-2300 Copenhagen, Denmark.)

SCIENCE/SOUTH PACIFIC
May. 53th Conference of the Australian & New Zealand Association for the Advancement of Science. Perth, Australia.
(ANZAAS, Box 873, GPO, Sydney 2001, Australia.)

IUPAC CONGRESS
June 4 - 12. 29th International Congress of Pure & Applied Chemistry. Cologne, Federal Republic of Germany.
(General Secretariat of the 29th IUPAC Congress, Dr. W. Fritsche, c/o Gesellschaft Deutscher Chemiker, P.O. Box 900440, D-6000 Frankfurt/M 90, Federal Republic of Germany.)

POLYETHYLENE
June 8 - 10. Golden Jubilee Conference "Polyethylenes 1933-1983: Past, Present and Future". London, UK.
(J. N. Ratcliffe, Secretary General, The Plastics and Rubber Institute, 11, Hobart Place, London SW1W OHL, UK.)

RING-OPENING REACTIONS
June. EUCHEM Conference on Synthetic uses of ring-opening reactions of aromatic heterocycles. Sweden.
(Prof. Sal Gronowitz, Dept. of Organic Chemistry 1, Chemical Centre, University of Lund, POB 740, S-220 07 Lund, Sweden.)

ELECTRON MICROSCOPY
Summer. EUCHEM Conference on High Resolution Electron Microscopy in Solid State Chemistry. Sweden.
(Prof. L. Kihlborg, Dept. of Inorganic Chemistry, Arrhenius Laboratory, University of Stockholm, S-106 91 Stockholm, Sweden.)

SMOKING AND HEALTH
July 10 - 15. 5th World Conference on Smoking and Health. Winnipeg, Canada.
(5th World Conference on Smoking and Health, P.O. Box 228, Station B, Ottawa, Ontario, Canada K1P 6C4.)

PROPERTIES OF COPOLYMERS
July 11 - 14. 24th Prague Microsymposium: Copolymers, Structure and Solution Properties. Prague, Czechoslovakia.
(Dr. P. Kratochvíl, c/o, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského nám. 2, 162 06 Prague 616, Czechoslovakia.)

ANALYTICAL CHEMISTRY
July 17 - 23. SAC 83 Conference and Exhibition, organised by the Analytical Division of the Royal Society of Chemistry. University of Edinburgh, Edinburgh, UK.
(Dr. J. M. Ottaway, Department of Pure & Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, UK.)

POLYMER STABILITY & PROCESSING
July 18 - 21. 25th Prague Microsymposium: Processing and Long-Term Stabilities of Hydrocarbon Polymers. Prague, Czechoslovakia.
(Dr. J. Pospísil, c/o, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n. 2, 162 06 Prague 616, Czechoslovakia.)

PERMAFROST
July 18 - 22. 4th International Conference on Permafrost. Fairbanks, Alaska, USA.
(Louis De Goes, Executive Sectretary, Polar Research Board, National Academy of Sciences, 2101 Constitution Ave., N. W. Washington, DC 20418, USA.)

CRYSTALLOGRAPHY
August. 8th European Crystallographic Meeting. Liège, Belgium.
(Prof. J. Toussaint, Institut de Physique B5, Université de Liège au Sart-Tilman, B-4000 Liège, Belgium.)

THEORETICAL CHEMISTRY
August 7 - 12. 8th Canadian Symposium on Theoretical Chemistry. Halifax, Nova Scotia, Canada.
(Dr. R. J. Boyd, Department of Chemistry, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J3.)

IUPAC GENERAL ASSEMBLY
August 18 - 26. 32nd IUPAC General Assembly. Lyngby/Copenhagen, Denmark.
(IUPAC Secretariat, 2-3, Pound Way, Cowley Centre, Oxford OX4 3YF, UK.)

SOLVENT EXTRACTION
August 26 - September 2. International Solvent Extraction Conference. Denver, CO, USA.
(ISEC '83, American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017, USA.)

AMERICAN CHEMICAL SOCIETY
August 28 - September 2. 186th National Meeting of the American Chemical Society. Washington, DC, USA.
(A. T. Winstead, American Chemical Society, 1155 16th Street NW, DC 20036, USA.)

TRACE ANALYSIS
August 28 - September 2. Int. Symposium on Microchemistry techniques and trace analysis. Amsterdam.
(Dr. W. J. van Oort, c/o Municipal Congress Bureau, O. Z. Achterburgwal 199, 1012 DK Amsterdam, Netherlands.)

FUNGI
August 28 - September 3. 3rd International Mycological Congress. Tokyo, Japan.
(Prof. K. Tubaki, Inst. of Biological Sciences, Univ. of Tsukuba, Sakura-Mura, Ibaraki 300-31, Japan.)

POLYMERIZATION OF HETEROCYCLES
September. Int. Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.
(Prof. Z. Jedliński, Polish Academy of Sciences, Polymer Institute, POB 49, Curie-Sklodowskeji 34, PL - 41 800 Zabrze, Poland.)

GEOCHEMICAL EXPLORATION
September. 10th International Geochemical Exploration Symposium. Helsinki, Finland.
(L. K. Kauranne. Organizing Committee, 10th IGES., The Geological Survey of Finland, Kivimiehentie 1, 02150 Espoo 15, Finland.)

MACROMOLECULES
September 5 - 9. 29th International Symposium on Macromolecules. Burcharest, Romania.
(Acad. Cristofor Simionescu, Institutul de Chimie Macromoleculara Petru Poni Aleea Grigore Ghica Voda Nr. 41A, Iasi, Romania.)

CRYSTAL GROWTH
September 12 -16. 7th International Conference on Crystal Growth. Stuttgart, Federal Republic of Germany.
(Dr. K. W. Benz, Secretary of ICCG-7, Kristallabor, Physikalisches Institut der Universität Pfaffenwaldring 57, 7000 Stuttgart 80, Federal Republic of Germany.)

FOOD TECHNOLOGY
September 18 - 23. 6th World Congress of Food Science and Technology. Dublin, Ireland.
(Dr. R. L. Joseph, c/o An Foras Taluntais, Dunsinea, Castleknock, Co. Dublin, Ireland.)

ENERGY RESOURCES
September 19 - 23. 12th World Energy Conference. New Delhi, India.
(E. Ruttley, World Energy Conference, 34 St. James' Street, London SW1A 1HD, UK.)

Chemistry International

is the news magazine of the

INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY (IUPAC)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

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Australian Academy of Science **(Australia)**
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Cover: Visitors to the Anthropology Museum at the University of British Columbia obtain a revealing glimpse of how the original inhabitants of Western Canada perceived their environment and explained its origin. Here, a recent sculpture depicts the Indian legend about a raven finding the first humans in a giant clamshell: a view quite different from modern concepts of biochemical evolution discussed only a short walk away by lecturers at the IUPAC Congress. See *Impressions of the IUPAC Congress.*

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